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TM-70-1031-3

TECHNICAL MEMORANDUM

TIME SERIES ANALYSIS PACKAGE (TSAP)
FOR
TERMINAL USE

Bellcomm



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BELLCOMM, INC.

955 L'ENFANT PLAZA NORTH, S.W., WASHINGTON, D.C. 20024

COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE-Time Series Analysis Package (TSAP) for TM-70-1031-3
Terminal Use

FILING CASE NO(S)- 103-7, 630

DATE- December 31, 1970

FILING SUBJECT(S) Time Series Analysis
(ASSIGNED BY AUTHOR(S))- Remote Terminal

AUTHOR(S)- G. R. Andersen
R. R. Singers

ABSTRACT

The time series analysis package (TSAP) presented here in the form of a user's manual, is a set of eleven interactive, functionally dependent time series programs which are accessible in any order from a remote terminal. TSAP has been designed so that an analyst can conduct a basic portion of the statistical calculations involved in multiple time series analysis during one session at a terminal. This allows the analyst to avoid the waiting times between outputs that occur with standard batch processing. In addition, it takes advantage of the sequential nature of the statistical computations involved in the analysis of time series.

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FROM: G. R. Andersen
R. R. Singers

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TECHNICAL MEMORANDUM

INTRODUCTION

The result of any particular statistical computation produces two types of information, one type leading to a conclusion and the other suggesting a particular direction for further analysis. With respect to the analysis of time series, the analyst usually has a general idea of the avenues of investigation likely to provide a broad preliminary understanding of the particular problem, e.g., how two series are statistically related or what is the statistical mechanism generating a single series. Since the direction of the investigation after the completion of any particular segment of the computations depends on the results of that segment, he must view the results of a large number of intermediate steps of the analysis before he can reach a point where a detailed evaluation and summary of the data can begin. Unfortunately, each segment usually requires at least one run on a computer and, more often than not, several hours elapse before the results can be viewed. On the other hand, the decision concerning the next step of the analysis can usually be made immediately, say in the length of time it would take the results to print out at a terminal.

TSAP, the terminal time series analysis package presented here, is designed to eliminate this miss-match between the computer and analyst by furnishing him with a set of interactive, functionally dependent time series programs; these programs are accessible in any order from a remote terminal.

The particular set of programs which are presently available in TSAP are necessary for the first steps in the analysis of any time series data. Further reduction of such data may require programs that are best kept in a batch mode (e.g., the method using the cross-spectral information of several series to improve the least squares estimates of the coefficients in a multiple time series regression). More programs will be added as they prove useful or are required in the solution of a particular problem. For this reason TSAP is provided with an index (cf., Appendix III) that may be consulted to determine what programs are available. The Bellcomm Univac 1108 implementation of TSAP is in file RRS*TSAP.

Descriptions of the TSAP programs are given in section 1 together with a brief nontechnical explanation of their use or meaning. This section also contains a diagram indicating the principal ways the programs in TSAP may be combined. The way in which data files are generated and used is described in Section 2.

Section 3 contains a series of examples (pages, 10, 22 and 30) that illustrate most of the present capabilities of TSAP and is intended as a users guide. ⁽¹⁾

Section 4 contains a discussion of program techniques and the flow charts of each of the programs; the listings are given in Appendix III. Some elementary remarks concerning time series together with the computational formulae used in the various programs are given in Appendix I. Details concerning the various filters available in TSAP are given in Appendix II.

1.0 PROGRAMS

This section contains a list of the programs in TSAP together with a brief description of their use.

(1) Data Transformations and Filters (FILTER)

The purpose of this program is to allow the user to prepare the data for time series analysis. For example, this might include transforming the series into the logarithms of its absolute values and then centering the resulting series at its mean in an effort to obtain a series that approximates a zero mean Gaussian time series. A series could be pre-whitened for spectral estimation by applying an appropriate high-pass filter; alternately, a trend in the series could be estimated or a cycle removed by using one or more of the available filters. The program is designed so that any subset of its transformations or filters may be applied sequentially to a particular time series with a single request for the element labeled FILTER. The transformations that are available in this program are listed when the user calls @filter; details concerning these transformations are given in Appendix II.

(2) Auto-Covariance and Auto-Correlation (ACF)

The sample auto-correlation function calculated with this program is a measure of the "memory" or inertia of the process generating the time series; this information can be used to some extent in model discrimination. The primary purpose of the auto-covariance function is in calculating the spectrum of the series.

⁽¹⁾ Although some remarks concerning statistics have been made to prevent misunderstanding and to motivate the use of a particular sequence of programs, this section is not meant to be tutorial in statistics; it assumes an elementary knowledge of this area.

(3) Partial-Auto-Correlation Function (PACF)

This function describes the correlation between two distinct members of a time series with the linear affect of intervening members removed. The program allows the user to calculate (up to) the first sixty values of the partial-auto-correlation function. It also computes the residual variance of auto-regression (a.r.) models,

$$y(t) = \alpha_0 + \alpha_1 y(t-1) + \dots + \alpha_p y(t-p) + \varepsilon(t) ,$$

up to order $p = 60$. On the basis of these results the user may determine the order of the best fitting a.r. model. Once the order is furnished, the program will print out the coefficients of the corresponding a.r. process. The appropriateness of the model may be judged by submitting the residuals of the fitted a.r. model to ACF and ASF.

(4) Auto-Spectrum (ASF)

An estimate of the auto-spectrum of a stationary time series is calculated and plotted at the terminal; if requested, its upper and lower 90% confidence limits are superimposed on the spectrum plot. One of the main purposes of this program is to determine which frequency bands contribute significantly to the total variance of the series. Another is in suggesting and testing the appropriateness of parametric models for the series being studied.

(5) Cross-Covariance (XCF)

This program is used primarily as data for the cross-spectral routine.

(6) Cross-Spectrum (XSF)

This program calculates estimates of the co-spectrum and the quadrature spectrum of pairs of (jointly stationary) time series. These quantities measure the covariance between the "in-phase" and the " $\pi/2$ out-of-phase" frequency components of the two series, respectively. The co- and quadrature spectrums, together with results from ASF, are used to calculate the coherence and phase of the pair of series. The coherence is a measure of linear relationships between frequency components of the series, while the phase measures lead and lag relationships. The arc-tanh of the coherence is plotted to obtain confidence bands which are independent of frequency.

(7) Least Squares Regression (LSRA and LSRP)

Least squares regression is included in the system for several purposes. It provides a method of estimating the trend component of a series, furnishes the standard errors of auto-regression coefficients (the order of the a.r. is determined with PACF) and gives preliminary estimates of the coefficients in a multiple regression on time series.

Two separate least squares regression programs⁽¹⁾ are included in TSAP: LSRA and LSRP. LSRA is a forward stepwise regression program that includes an analysis of variance table at each step together with a table of observed values, expected values and percent deviation, printed out at the request of the user. LSRP is a backward regression program whose main feature is that it yields predicted values with upper and lower prediction limits.

(8) Save

After an application of the program FILTER the user is asked whether or not he wants the transformed series stored. If the answer is yes and the data format is specified, then the series is automatically stored, but the user must supply the statement @SAVE FILTER,[series name] to be able to reference the series for later use.⁽²⁾ Similar statements are required after executing the LSRA, LSRP or COMB programs (e.g., @SAVE LSRA,[series name]).

(9) Combination of Series (COMB)

Given two time series of the same length, this program enables the user to perform term by term addition (ADD), subtraction (SUB), multiplication (MPY) or division (DIV) of the two series. COMB also allows one to concatenate (CON) series of arbitrary length.

(10) MATH Conversion (MATHCON)

In some applications, the user requires a series of values of some known or constructed function and a way to easily combine this series algebraically with an observed series

(1) Both of these programs are modifications of regression programs available in the UNIVAC Stat-pack program library.

(2) This control statement stores the series in the TPF; if the user has a catalogued file he may store the series in this file by typing @SAVE FILTER,[FILE.SERIES NAME].

being analyzed with TSAP. This can be accomplished without leaving the terminal by generating the required series with MATH and combining it in TSAP (using COMB) with the observed series. MATHCON eliminates the incompatibilities in I/O⁽¹⁾ between the two series.

Additional programs that are available for batch runs, but have not been included in TSAP at the present time include

(A) Time Series Regression (TSR)⁽²⁾

This program combines the preliminary least squares estimates in a multiple regression on time series with cross-spectral information between series to produce asymptotically efficient estimates of the regression coefficients.

(B) Histogram and Scatter Plot Programs (HIST, SCAT)⁽²⁾

Work is in progress on the following programs: a means of estimating mixed regression, auto-regression and moving average models and a program for forecasting with such models.

The efficiency and effectiveness of TSAP would be enhanced with the addition of CRT (Cathode Ray Tube) display capabilities to allow more outputs. This would provide the user with a more comprehensive system containing programs dealing with graphics.

Another possible improvement which will be looked into concerns the formatting structure. At present each input or output series requires a format; this reduces data format conversions at the expense of answering questions. An alternative method would be to have a fixed format, say G20.10, in which all data is read and written. This would reduce the number of user responses but also reduce the generality of the input data structures. A way around this is to add an option, say F, to allow the present dialogue to be used.

The following diagram indicates the ways in which the TSAP programs may be linked together in applications. These will be further described by means of the examples given in Section 3.

(1) MATH "SAVED" elements are in fixed point and floating point notation, using *10**n instead of the FORTRAN E+n. A format of (G20.10) will suffice to read the converted series.

(2) TSR will be documented in the near future; HIST is a corrected UNIVAC Stat-pack routine and SCAT is obtainable from R. R. Singers.

TSAP

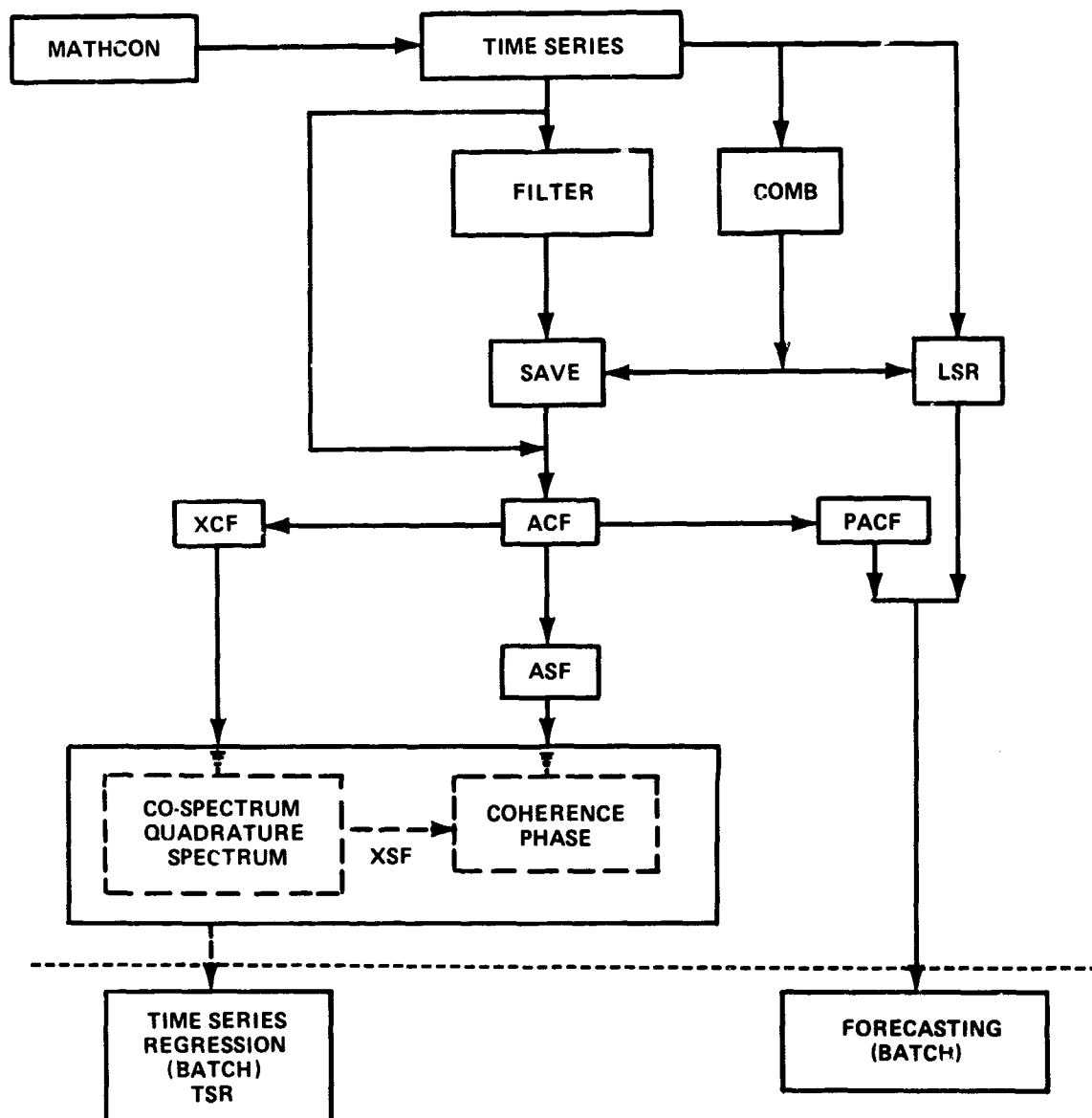


FIGURE 1

2.0 GENERATION AND USE OF STORED DATA ELEMENTS

The first step in applying TSAP to a particular set of time series data is to make this data accessible from the terminal. This can be accomplished by using the EXEC 8 control statements @ELT and @ADD. The control statement ELT allows the user to place the data into the machine, via the card reader or the terminal, with a name attached to it. This name together with the @ADD statement makes the data available for use in TSAP.

The ELT processor allows one to generate a data element in a file using the following control card (starting in column 1):

```
@ELT,I,QUAL*FILE.ELEMENT
```

where . indicates one or more spaces.

QUAL*FILE. is the name of the catalogued file⁽¹⁾ into which the user wants the data stored. This field may be left blank, in which case the user temporary file, TPF\$, is used.

ELEMENT is the name of the data series. The data follows immediately after this card and the element is terminated when the next control card is read.

When the data is asked for within TSAP, the element can be obtained by using the following control card (starting in column 1):

```
@ADD,QUAL*FILE.ELEMENT
```

The following are four examples of ELT processor use:

- 1) For external card deck
 - (a) without previously catalogued file
 1. @RUN,/NR.INIT,ID,PROJECT,15,150
 2. @ASG,CP.QUAL*FILE.,F2
 3. @ELT,IL.QUAL*FILE.ELEMENT
 4. (Data cards)
 5. @FIN

⁽¹⁾ See [14] for definition of catalogued file.

(b) with previously catalogued file

1. @RUN,/NR.INIT,ID,PROJECT,15,150
2. @ASG,A.QUAL*FILE.
3. @ELT,IL QUAL*FILE.ELEMENT
4. (Data cards)
5. @FIN

2) For terminal input

(a) without previously catalogued file

1. @RUN.INIT,ID,PROJECT,70
2. @ASG,CP.QUAL*FILE.,F2
3. @ELT,I.QUAL*FILE.ELEMENT
4. (Type in data)

(b) with previously catalogued file

1. @RUN.INIT,ID,PROJECT,70
2. @ASG,A.QUAL*FILE.
3. @ELT,I.QUAL*FILE.ELEMENT
4. (Type in data)

I/O. (1) It is necessary for all data to be in FORTRAN formatted

(1) For information on formats see [13].

3.0 USING TSAP

The mechanics of using TSAP will now be explained by means of several examples. These examples fall into essentially three groups and begin on pages 10, 22 and 30.

The first group involves a single time series and uses that portion of TSAP indicated in Figure 2. The first example within this group illustrates spectral estimation using a Tukey window at two different bandwidths. These spectra together with their 90% confidence bands are plotted against frequency in cycles per unit time. The spectrum of the time series is then estimated by means of both the Daniell and Tukey windows and plotted against period with no confidence bands. The second and third examples within the first group illustrate two types of Goodman filters applied to the series and the spectra of the resulting series.

To aid the reader, an arrow has been added to the left margin of the terminal printout each time a new request is made for a TSAP program.

Finally, it should be remembered that each group of examples was executed in one session at a remote terminal; depending on the user, the amount of his time required for computations similar to those in one of these groups would be between 10 and 30 minutes.

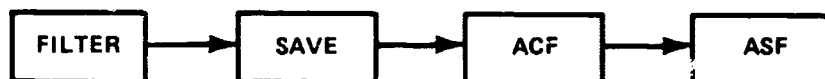


FIGURE 2

We will assume that the series has been stored in the machine, as explained in the previous section, under the name yl0e; it contains 362 terms.

In order to activate the terminal, assign the file and copy it over into a temporary file we type the terminal number, say

BT11,

followed by

@RUN, INITIALS, ACCOUNT, PROJECT, MAXTIME, MAXPAGES

@ASG, AX, RRS*TSAP.

@COPY, P, RRS*TSAP., TPF\$.

The first program called is @filter⁽¹⁾:

➔ @filter

'FILTER' CONTAINS THE FOLLOWING FILTERS:

CENTER, EXP, LOG, DIFF, 10**, LOG10, SQRT, LAG, ABS, TUKEY (HIGH AND LOW PASS), GOODMAN, SCALE.

TO TERMINATE THE FILTER SEQUENCE, REPLY WITH 'END'.

THE FINAL SERIES IS STORED ON UNIT 8 (IF DESIRED).

LENGTH OF SERIES TO BE READ IN?

362

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add y10e

LENGTH OF SERIES TO BE USED?

362

MEAN= .37433816+01

LENGTH= 362

← *The entire series that is stored in the data file must be read in at this point.*

← *Here we could have deleted any number, m, of consecutive terms from the end of the series by typing 362-m.*

FILTER?

center

MEAN= .35338186-05

LENGTH= 362

← *After each request for a filter the mean of the filtered series together with its length is automatically printed out.*

FILTER?

end

DO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?

no

DO YOU WANT THE FINAL SERIES STORED (YES/NO)?

yes

OUTPUT DATA FORMAT?

(4e15.8)

SERIES STORED.

FILTER TERMINATES.

➔ @save filter, y1000

(1) The underlined quantities are the users responses to the preceeding program questions. The italicized type indicates explanatory comments that have been placed onto the terminal printout to aid the reader of this memorandum.

The name of the y10e series after the above transformations is y1000. The auto-correlation function of y1000 is calculated next:

→ @acf

ACF COMPUTES THE AUTO-COVARIANCE/CORRELATION FUNCTION OF A SERIES. THE COVARIANCES ARE STORED ON UNIT 1 IN BINARY (IF DESIRED) IN CONSECUTIVE ORDER.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

cor

LENGTH OF SERIES?

362

NUMBER OF LAGS (ZERO INCLUDED)?

41

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add y1000

0	.10000000+01	13	.18489365-01	26	.11289490+00
1	.46415033+00	14	.11077084+00	27	.15901410+00
2	.17615860+00	15	.17462706+00	28	.11500745+00
3	.49235427-01	16	.35404109-01	29	.93957893-01
4	-.50011224-01	17	-.16164341-01	30	.97580075-01
5	-.26090787-01	18	.35023679-03	31	.59549038-01
6	-.19535766-01	19	.60941407-01	32	-.80215645-02
7	-.31009051-01	20	.61706792-01	33	-.28728484-01
8	-.47952917-01	21	.17506226-01	34	.53134954-01
9	.23769772-02	22	-.79266704-01	35	.18498416-01
10	.21561115-01	23	-.79293265-01	36	.18898459-01
11	.10452646-02	24	.13103552-01	37	-.31084192-02
12	.25509858-02	25	.82080608-01	38	.88336019-01
				39	.14070644+00
				40	.96740634-01

VARIANCE= .34657791+00

MEAN= .35338186-05

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCE STORED.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

end

ACF TERMINATES.

→ @asf

ASF COMPUTES THE AUTO SPECTRUM FUNCTION.

IT IS ASSUMED THAT ACF WAS CALLED AND THE DESIRED COVARIANCES STORED.

THE AUTO-SPECTRA ARE STORED ON UNIT 2 (IF DESIRED) CONSECUTIVELY.

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

18

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

33

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

yes

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?

freq.

AUTO-SPECTRUM:

FREQ.	SPECTRUM
.0000	.74730+00
.0156	.74350+00
.0313	.74541+00
.0469	.76602+00
.0625	.78415+00
.0781	.76448+00
.0938	.70337+00
.1094	.62974+00
.1250	.56432+00
.1406	.50291+00
.1563	.44168+00
.1719	.39207+00
.1875	.35903+00
.2031	.32513+00
.2188	.27371+00
.2344	.21620+00
.2500	.17947+00
.2656	.17243+00
.2813	.18018+00
.2969	.18700+00
.3125	.18969+00
.3281	.18850+00
.3438	.18017+00
.3594	.16534+00
.3750	.15253+00
.3906	.14782+00
.4063	.14651+00
.4219	.14004+00
.4375	.12689+00
.4531	.11207+00
.4688	.99940-01
.4844	.91983-01
.5000	.89126-01

THE 90% CONFIDENCE LIMITS FOR NU=57⁽¹⁾ ARE: CU= 1.39722 , CL= .75097

⁽¹⁾ NU, the number of degrees of freedom of the spectral estimator, is defined in Appendix I.

THE SORT OF VARIANCE RATIO IS: 19.3118
DO YOU WANT THE SPECTRUM STORED (YES/NO)?
no
DO YOU HAVE ANOTHER SERIES (YES/NO)?
yes
IS THE SERIES THE SAME (YES/NO)?
(1)
yes
DATA SPACING?
1.
WINDOW TO BE USED (TUKEY/DANIELL)?
tukey
BANDWIDTH PARAMETER?
33
NUMBER OF FREQUENCY POINTS TO BE VIEWED?
33
DO YOU WANT CONFIDENCE LIMITS (YES/NO)?
yes
DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?
freq.

(1) This illustrates the usual method of calculating the spectrum at successively smaller bandwidths ("window closing") in order to determine the structure of the true but unknown spectrum.

AUTO-SPECTRUM:

FREQ.	SPECTRUM
.0000	.88953+00
.0156	.73221+00
.0313	.62610+00
.0469	.73374+00
.0625	.90672+00
.0781	.84932+00
.0938	.62948+00
.1094	.59679+00
.1250	.56681+00
.1406	.56516+00
.1563	.45911+00
.1719	.26265+00
.1875	.35751+00
.2031	.45512+00
.2188	.27104+00
.2344	.12386+00
.2500	.15475+00
.2656	.20220+00
.2813	.19860+00
.2969	.16452+00
.3125	.16827+00
.3281	.22187+00
.3438	.20527+00
.3594	.14452+00
.3750	.12858+00
.3906	.14862+00
.4063	.16991+00
.4219	.14789+00
.4375	.11107+00
.4531	.10553+00
.4688	.11495+00
.4844	.91251-01
.5000	.64649-01

THE 90% CONFIDENCE LIMITS FOR NU=30 ARE: CU= 1.63145 ,CL= .68925
 THE SQRT OF VARIANCE RATIO IS: 26.148 %
 DO YOU WANT THE SPECTRUM STORED (YES/NO)?

no

In this last example we see that the square root of the variance ratio is about 26%; that is, fractional errors of about 26% in either direction can be expected. It was decided that with this length of series it would be difficult to obtain both high resolution (small bandwidth) and reliability. However, suppose for illustration that a bandwidth parameter of 33 gives us the proper resolution and then compare the spectral estimate obtained using the Daniell window with that obtained using the Tukey window.

→ @asf,n⁽¹⁾
DATA SPACING?
1.
WINDOW TO BE USED (TUKEY/DANIELL)?⁽²⁾
daniell
BANDWIDTH PARAMETER?
33
NUMBER OF COVARIANCES TO BE USED?
362
NUMBER OF FREQUENCY POINTS TO BE VIEWED?
33
DO YOU WANT CONFIDENCE LIMITS (YES/NO)?
no
DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?
period

(1) The "n" option is supplied to suppress the initial commentary for the experienced user.

(2) If there are N terms in the series, then to employ the Daniell window, N covariances (including the variance) must be calculated in ACF and used in responding to the 4th question in ASF. If any number of covariances less than this number are either calculated or used, a request for the Daniell window will yield a truncated Daniell window.

AUTO-SPECTRUM:

PERIOD	SPECTRUM
99.9999	.88676+00
64.0000	.75138+00
32.0000	.63410+00
21.3333	.69779+00
16.0000	.10041+01
12.8000	.85815+00
10.6667	.50042+00
9.1429	.57420+00
8.0000	.59914+00
7.1111	.62584+00
6.4000	.43762+00
5.8182	.23736+00
5.3333	.43552+00
4.9231	.45420+00
4.5714	.21520+00
4.2667	.10984+00
4.0000	.16376+00
3.7647	.19306+00
3.5556	.19815+00
3.3684	.16836+00
3.2000	.13186+00
3.0476	.24439+00
2.9091	.23136+00
2.7826	.14539+00
2.6667	.13965+00
2.5600	.12276+00
2.4615	.16503+00
2.3704	.15110+00
2.2857	.10209+00
2.2069	.11633+00
2.1333	.11029+00
2.0645	.95078-01
2.0000	.67187-01

DO YOU WANT THE SPECTRUM STORED (YES/NO)?

no

DO YOU HAVE ANOTHER SERIES (YES/NO)?

yes

IS THE SERIES THE SAME (YES/NO)?

yes

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

33

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

33

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

no

DO YOU WANT FREQUENCY(FREQ.) OR PERIOD(PERIOD) DISPLAYED?
period

AUTO-SPECTRUM

PERIOD	SPECTRUM
99.9999	.88953+00
64.0000	.73221+00
32.0000	.62610+00
21.3333	.73374+00
16.0000	.90672+00
12.8000	.84932+00
10.6667	.62948+00
9.1429	.59679+00
8.0000	.56681+00
7.1111	.56516+00
6.4000	.45911+00
5.8182	.26265+00
5.3333	.35751+00
4.9231	.45512+00
4.5714	.27104+00
4.2667	.12386+00
4.0000	.15475+00
3.7647	.20220+00
3.5556	.19860+00
3.3684	.16452+00
3.2000	.16827+00
3.0476	.22287+00
2.9091	.20527+00
2.7826	.14452+00
2.6667	.12858+00
2.5600	.14862+00
2.4615	.16991+00
2.3704	.14789+00
2.2857	.11107+00
2.2069	.10553+00
2.1333	.11495+00
2.0645	.91251-01
2.0000	.64649-01

DO YOU WANT THE SPECTRUM STORED(YES/NO)?

no

DO YOU HAVE ANOTHER SERIES(YES/NO)?

no

ASF TERMINATES.

We now return to the filter program and illustrate the use of the Goodman filters (cf., Appendix III):

→ @filter,n
 LENGTH OF SERIES TO BE READ IN?
362
 INPUT DATA FORMAT?

(4e15.8)INPUT DATA:@add y1000LENGTH OF SERIES TO BE USED?362

MEAN= .35338186-05

LENGTH= 362

FILTER?

goodmanLENGTH OF MOVING AVERAGE (ODD NUMBER)?41NUMBER OF TRIANGLES?1DATA SPACING?1.HIGH PASS (HIGH), LOW PASS (LOW), PASS BAND (PASS) OR REJECT BAND (REJECT)?rejectCENTER FREQUENCY?.074

MEAN= -.25713835-01

LENGTH= 322

FILTER?

endDO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?noDO YOU WANT THE FINAL SERIES STORED (YES/NO)?yesOUTPUT DATA FORMAT?(4e15.8)SERIES STORED.FILTER TERMINATES.→ @save filter, y1000r13

Thus, after filtering the series consists of 322 terms; 20 terms off of each end of the series y10b were required to remove the spectral content at the frequency .074 (cycles/day) or at 13.5 (days). The filter is triangular and frequencies in a neighborhood, of length .1, centered at .074 are attenuated. The new series was saved, and its auto covariance function was calculated and stored. The known affect (Appendix I) of this filter on the spectrum may be observed by calculating its spectrum:

→ @asf,nDATA SPACING?1.WINDOW TO BE USED (TUKEY/DANIELL)?tukeyBANDWIDTH PARAMETER?33NUMBER OF FREQUENCY POINTS TO BE VIEWED?33DO YOU WANT CONFIDENCE LIMITS (YES/NO)?noDO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?period

AUTO-SPECTRUM

PERIOD	SPECTRUM
99.9999	.95803+00
64.0000	.73078+00
32.0000	.46987+00
21.3333	.28421+00
16.0000	.77602-01
12.8000	.29739-01
10.6667	.17326+00
9.1429	.40914+00
8.0000	.53168+00
7.1111	.57579+00
6.4000	.44403+00
5.8182	.25050+00
5.3333	.37526+00
4.9231	.49792+00
4.5714	.30044+00
4.2667	.13079+00
4.0000	.16472+00
3.7647	.22356+00
3.5556	.21855+00
3.3684	.18145+00
3.2000	.18210+00
3.0476	.23152+00
2.9091	.20816+00
2.7826	.14103+00
2.6667	.13133+00
2.5600	.14793+00
2.4615	.16166+00
2.3704	.14852+00
2.2857	.11957+00
2.2069	.11832+00
2.1333	.12439+00
2.0645	.91969-01
2.0000	.63272-01

DO YOU WANT THE SPECTRUM STORED(YES/NO)?

no

DO YOU HAVE ANOTHER SERIES(YES/NO)?

no

ASF TERMINATES.

In order to illustrate the use of a low pass filter and view its affect on the spectrum of the filtered series we return to FILTER and call an adaptation of Goodman's trapezoidal filter (cf., Appendix II):

FILTER?

goodman

LENGTH OF MOVING AVERAGE(ODD NUMBER)?

41

NUMBER OF TRIANGLES?

5

HIGH PASS(HIGH), LOW PASS(LOW), PASS BAND(PASS) OR REJECT BAND(REJECT)?

low

DATA SPACING?

1.

CUT-OFF FREQUENCY IS .2250000

DO YOU WANT TO CHANGE INPUT VALUES(YES/NO)?

no

MEAN= -.27138643-01

LENGTH= 322

FILTER?

end

DO YOU WANT TO SEE PART OF THE SERIES(YES/NO)?

no

DO YOU WANT THE FINAL SERIES STORED(YES/NO)?

yes

OUTPUT DATA FORMAT?

(4e15.8)

SERIES STORED.

FILTER TERMINATES.

➤ @save filter, y10low

➤ @acf,n

DO YOU WANT COVARIANCE(COV),CORRELATION(COR) OR END?

cor

LENGTH OF SERIES?

322

NUMBER OF LAGS(ZERO INCLUDED)?

33

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add y10low

0	.10000000+01	12	-.25210146-01	24	-.73984930-02
1	.74639370+00	13	.52257420-01	25	.10968976+00
2	.24772014+00	14	.16964401+00	26	.16955650+00
3	-.62077395-01	15	.18732763+00	27	.17834130+00
4	-.58770868-01	16	.83261370-01	28	.18380984+00
5	.31103434-01	17	-.17561690-01	29	.19426458+00
6	.13050401-01	18	-.22876046-02	30	.17436985+00
7	-.49688995-01	19	.92481258-01	31	.10661660+00
8	-.21093979-01	20	.12817274+00	32	.32856451-01
9	.69109890-01	21	.42624820-01		
10	.87358192-01	22	-.76860528-01		
11	.14558297-01	23	-.10038714+00		

VARIANCE= .26590697+00

MEAN= -.27138641-01

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCE STORED.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

end

ACF TERMINATES.

→ @asf,n

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

33

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

33

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

no

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?

freq.

AUTO-SPECTRUM:

FREQ.	SPECTRUM
.0000	.97734+00
.0156	.75601+00
.0313	.56642+00
.0469	.64053+00
.0625	.79873+00
.0781	.76774+00
.0938	.62412+00
.1094	.62409+00
.1250	.58374+00
.1406	.58306+00
.1563	.45604+00
.1719	.25828+00
.1875	.39156+00
.2031	.50674+00
.2188	.29786+00
.2344	.10037+00
.2500	.37529-01
.2656	.94984-02
.2813	.17673-02
.2969	.11131-02
.3125	.14980-02
.3281	.15829-02
.3438	.15418-02
.3594	.12205-02
.3750	.11983-02
.3906	.10520-02
.4063	.11808-02
.4219	.11860-02
.4375	.10052-02
.4531	.98564-03
.4688	.12136-02
.4844	.10427-02
.5000	.88202-03

DO YOU WANT THE SPECTRUM STORED (YES/NO)?

no

DO YOU HAVE ANOTHER SERIES (YES/NO)?

no

ASF TERMINATES.

The second group involves two time series and uses that portion of TSAP shown in Figure 3. This example shows the sequence required to obtain the coherence and phase.

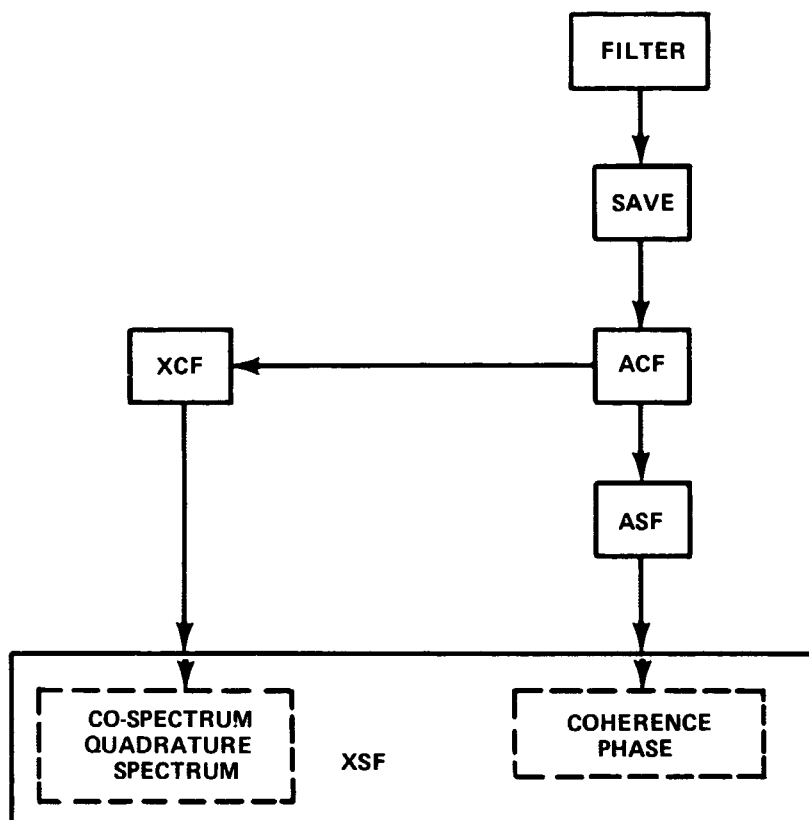


FIGURE 3

Since the filter program has already been demonstrated, we will assume that both series are prepared for spectral analysis and have been saved under the names ybh and sskp⁽¹⁾. The first program called is ACF:

► @acf,n

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

cor

LENGTH OF SERIES?

362

NUMBER OF LAGS (ZERO INCLUDED, ?

33

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add ybh

⁽¹⁾ SSKP is saved in the file gra while ybh is in TPF\$.

0	.10000000+01	11	-.31216709-01	22	-.63481236-01
1	.60598906+00	12	-.34091541-01	23	-.51319714-01
2	.26923198+00	13	-.21461296-01	24	.28734243-01
3	.75024208-01	14	.30060796-01	25	.97583456-01
4	-.63190014-01	15	.52854193-01	26	.11406376+00
5	-.58960785-01	16	-.37186533-01	27	.13826372+00
6	-.56973809-01	17	-.79431379-01	28	.12823801+00
7	-.35041797-01	18	-.37290229-01	29	.14123514+00
8	-.18516959-01	19	.24989689-01	30	.14814627+00
9	-.64888234-02	20	.19790754-01	31	.98589633-01
10	.41145700-02	21	-.21608890-01	32	.20618195-01

VARIANCE= .14191380+00

MEAN= .40113709-05

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCE STORED.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

cor

LENGTH OF SERIES?

362

NUMBER OF LAGS (ZERO INCLUDED)?

33

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add gra.sskp

0	.10000000+01	11	.34387418-01	22	.15657139-01
1	.48397417+00	12	.85019480-01	23	-.32998001-02
2	.16358888+00	13	.18485049-01	24	.19564041-02
3	.34291061-01	14	.71320571-01	25	.20206913-01
4	-.82355165-01	15	.29714237-01	26	.47620085-01
5	-.48359534-01	16	-.17095344-01	27	.65758524-01
6	-.44122326-01	17	.44739600-02	28	.61266199-01
7	-.32026744-01	18	.17245420-02	29	.77879018-02
8	-.34230735-01	19	.19832755-01	30	-.39413126-01
9	-.71012059-02	20	.87463330-02	31	-.93015461-02
10	.96968840-02	21	.34905837-02	32	-.10927683-01

VARIANCE= .11447779+01

MEAN= .40104705-05

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCE STORED.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

end

ACF TERMINATES.

@asf,n

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

33

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

33

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

no

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?

period

AUTO-SPECTRUM:

PERIOD	SPECTRUM
99.9999	.33286+00
64.0000	.34424+00
32.0000	.39179+00
21.3333	.38674+00
16.0000	.38696+00
12.8000	.39049+00
10.6667	.33785+00
9.1429	.31070+00
8.0000	.26813+00
7.1111	.23930+00
6.4000	.18930+00
5.8182	.10181+00
5.3333	.10485+00
4.9231	.13927+00
4.5714	.91497-01
4.2667	.44466-01
4.0000	.50774-01
3.7647	.62834-01
3.5556	.55293-01
3.3684	.41898-01
3.2000	.44758-01
3.0476	.53232-01
2.9091	.46325-01
2.7826	.38710-01
2.6667	.40210-01
2.5600	.44652-01
2.4615	.46159-01
2.3704	.35595-01
2.2857	.23144-01
2.2069	.18414-01
2.1333	.19327-01
2.0645	.18276-01
2.0000	.15677-01

DO YOU WANT THE SPECTRUM STORED (YES/NO)?

yes

SPECTRUM STORED.

DO YOU HAVE ANOTHER SERIES (YES/NO)?

yes

IS THE SERIES THE SAME (YES/NO)?

no

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

33

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

33

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

no

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?

period

AUTO-SPECTRUM:

PERIOD	SPECTRUM
99.9999	.25931+01
64.0000	.23221+01
32.0000	.21251+01
21.3333	.23342+01
16.0000	.27527+01
12.8000	.29730+01
10.6667	.26473+01
9.1429	.21566+01
8.0000	.17926+01
7.1111	.17529+01
6.4000	.16743+01
5.8182	.13744+01
5.3333	.11421+01
4.9231	.97125+00
4.5714	.83534+00
4.2667	.66678+00
4.0000	.61252+00
3.7647	.67283+00
3.5556	.62783+00
3.3684	.50060+00
3.2000	.49504+00
3.0476	.61500+00
2.9091	.69453+00
2.7826	.60262+00
2.6667	.39595+00
2.5600	.36967+00
2.4615	.53734+00
2.3704	.56806+00
2.2857	.37592+00
2.2069	.20381+00
2.1333	.17313+00
2.0645	.23317+00
2.0000	.27656+00

DO YOU WANT THE SPECTRUM STORED (YES/NO)?

yes

SPECTRUM STORED.

DO YOU HAVE ANOTHER SERIES (YES/NO)?

no

ASF TERMINATES.

→ @xcf

XCF COMPUTES THE CROSS-COVARIANCE/-CORRELATION FUNCTION OF TWO SERIES. IT IS ASSUMED THAT THE AUTO-COVARIANCES OF THE TWO SERIES ARE STORED ON UNIT 1. THE CROSS-COVARIANCES ARE STORED ON UNIT 1 (IF DESIRED) AFTER THE AUTO-COVARIANCES.

DO YOU WANT COVARIANCE (COV) OR CORRELATION (COR)?

cor

INPUT DATA FORMAT OF SERIES 1?

(4e15.8)

INPUT DATA OF SERIES 1:

@add ybh

INPUT DATA FORMAT OF SERIES 2?

(4e15.8)

INPUT DATA OF SERIES 2:

@add gra.sskp

CROSS-COR. FOR SERIES 1 VS. 2.

0	-.31068495+00	11	.68149552-01	22	-.19024821-01
1	-.32688250+00	12	.19405418-01	23	.28423370-01
2	-.23031710+00	13	.67258818-01	24	.65661986-01
3	-.15878268+00	14	.33894985-01	25	.71599943-01
4	-.97850593-02	15	.15917252-01	26	.77692746-01
5	.70688121-02	16	.44837943-01	27	.54928598-01
6	-.78098371-02	17	.68729260-01	28	.34432033-01
7	.32410393-04	18	.30546963-01	29	-.31944079-02
8	-.14137039-01	19	-.21630687-01	30	-.27489146-01
9	.92356610-02	20	-.22341036-01	31	-.65063784-01
10	.56534438-01	21	-.36277876-01	32	-.22737283-01

CROSS-COR. FOR SERIES 2 VS. 1.

0	-.31068495+00	11	.68149863-02	22	.22976052-01
1	.16895355+00	12	-.29895622-01	23	-.29432392-01
2	.40202706+00	13	.19673600-01	24	-.10881614+00
3	.40670389+00	14	-.28525013-01	25	-.13978173+00
4	.38908781+00	15	-.15708253-01	26	-.98344548-01
5	.27146963+00	16	.39682694-01	27	-.48471882-01
6	.16915689+00	17	.24792291-01	28	.39428172-01
7	.90782260-01	18	-.34359416-01	29	.11597794+00
8	.41205884-01	19	-.67074667-01	30	.10655324+00
9	.65060452-02	20	-.42766543-01	31	.97206097-01
10	.64103368-02	21	.89084057-02	32	.10046362+00

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCES STORED.

XCF TERMINATES.

➔ @xsf

XSF COMPUTES THE CROSS-SPECTRA FUNCTIONS FOR TUKEY WINDOW.

IT IS ASSUMED THAT THE AUTO- AND CROSS-COVARIANCES ARE STORED ON UNIT 1 AND THAT THE AUTO-SPECTRA ARE STORED ON UNIT 2.

THE CROSS-SPECTRA ARE STORED ON UNIT 2 AFTER THE AUTO-SPECTRA (IF DESIRED).

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD)

DISPLAYED?

freq

FREQ. ARCTANH(COHERENCE) FOR SERIES 1 VS. 2 .

.0000	.45577+00	+
.0156	.37510+00	+
.0313	.14873+00	+
.0469	.17172+00	+
.0625	.24303+00	+
.0781	.33788+00	+
.0938	.52812+00	+
.1094	.63082+00	+
.1250	.67882+00	+
.1406	.71782+00	+
.1563	.73696+00	+
.1719	.55091+00	+
.1875	.35149+00	+
.2031	.45226+00	+
.2188	.51547+00	+
.2344	.60792+00	+
.2500	.75909+00	+
.2656	.69457+00	+
.2813	.49093+00	+
.2969	.44707+00	+
.3125	.84579+00	+
.3281	.12234+01	+
.3438	.10487+01	+
.3594	.78859+00	+
.3750	.64568+00	+
.3906	.59831+00	+
.4063	.56528+00	+
.4219	.54029+00	+
.4375	.41398+00	+
.4531	.11776+00	+
.4688	.13592+00	+
.1844	.36685+00	+
.5000	.45305+00	+

NU= 30.

.000	.00000
.0156	-.52353+01
.0313	-.39472+02
.0469	-.13202+03
.0625	-.14719+03
.0781	-.16059+03
.0938	-.16853+03
.1094	-.17007+03
.1250	-.17200+03
.1406	-.17227+03
.1563	-.17250+03
.1719	-.17193+03
.1875	-.16744+03
.2031	-.17176+03
.2188	-.17493+03
.2344	-.17545+03
.2500	-.17624+03
.2656	-.17626+03
.2813	-.17471+03
.2969	-.17732+03
.3125	-.17998+03
.3281	-.17938+03
.3438	-.17893+03
.3594	-.17812+03
.3750	-.17657+03
.3906	-.17693+03
.4063	-.17884+03
.4219	-.17872+03
.4375	-.17625+03
.4531	-.17222+03
.4688	.17008+03
.4844	.17622+03
.5000	.18000+03

-100-

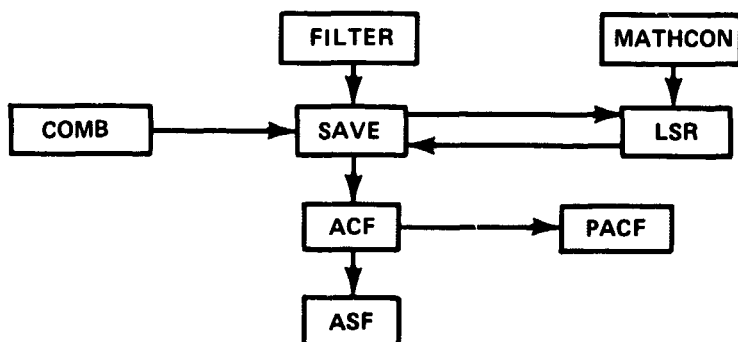
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DO YOU WANT THE CO-SPECTRA AND QUADRATURES
STORED FOR TIME SERIES REGRESSION (YES/NO)?

no
XSF TERMINATES.

THE NEXT GROUP USES THE FOLLOWING PARTS OF TSAP:



The main object of this group of examples is to illustrate the regression and partial auto-correlation programs. This is accomplished by regressing one series onto two others with LSRA and then applying ACF and PACF to the residuals. On the basis of the output from PACF, the residual series is modeled as a second order auto-regression. The residuals corresponding to this model are obtained by successive applications of FILTER and COMB and then examined using PACF and ASF.

The final example of this group illustrates LSRP.

The forward stepwise regression program, LSRA, is illustrated first by regressing a series x1, consisting of 123 terms, onto two series, y1 and timel23, of the same length. The series time 123 consists of the positive integers from 1 to 123 and was generated using MATH and MATHCON:

→ @asg,a gra.

@math

MATH VERSION 3. WHAT CAN I DO FOR YOU?

1.1 set a(i)=i.

do part 1 for i=1(1)123.

use file gra.

ROGER.

save a as a.

DONE.

→ @mathcon,i ,gra*gra.timel23

READY.

@add gra*gra.a

@nop

MATHCON TERMINATES.

→ @lsra

LSRA IS A STEPWISE MULTIPLE REGRESSION PROGRAM
WITH ANALYSIS OF VARIANCE PRINTOUT.
THE RESIDUALS ARE STORED ON UNIT 8 (IF DESIRED).

NUMBER OF OBSERVATIONS.

123

NUMBER OF VARIABLES (DEPENDENT AND INDEPENDENT)?

3

F LEVEL

3.25

DEPENDENT VARIABLE FORMAT?

(4e15.8)

DEPENDENT VARIABLE DATA:

@add x1

INDEPENDENT VARIABLE 1 FORMAT?

(4e15.8)

INDEPENDENT VARIABLE 1 DATA:

@add y1

INDEPENDENT VARIABLE 2 FORMAT?

(e15.8)

INDEPENDENT VARIABLE 2 DATA:

@add gra.timel23

MEANS:

1 .39642049+01 2 .62000000+02

CORRELATION COEFFICIENTS:

1 VS 2 = -.116816

1 VS Y = .787702 2 VS Y⁽¹⁾ = .515992

STANDARD ERROR OF Y = .478109+00

SSVAR=*****	SSRES=	27.887794	DFRES=	122.000000
MSRES=	.228588	T=	.000000	MULTCOR=
				.000000

STEP NO. 1

VARIABLE ENTERING: 1

FLEVEL 197.819456

STANDARD ERROR OF Y .295757

CONSTANT .289935+00

VARIABLE	COEFFICIENT	STD. ERROR OF COEFF.
X 1	.92686272+00	.65899315-01

SSVAR=	17.303675	SSRES=	10.584119	DFRES=	121.000000
MSRES=	.087472	T=	14.064830	MULTCOR=	.620475

(1) In the computer responses, Y is a generic symbol for the dependent variable while the symbol X, with subscripts, represents an independent variable. The first X-variable entered is that independent variable having the highest correlation with the dependent variable.

STEP NO. 2
 VARIABLE ENTERING: 2
 FLEVEL 9494.080078
 STANDARD ERROR OF Y .033180
 CONSTANT -.558482+00

VARIABLE	COEFFICIENT	STD. ERROR OF COEFF.
X 1	.10115818+01	.74439476-02
X 2	.82666745-02	.84840725-04

SSVAR= 10.452011 SSRES= .132108 DFRES= 120.000000
 MSRES= .001101 T= 97.437571 MULTCOR= .995263

DO YOU WANT TO SEE SOME OF THE DEVIATIONS (YES/NO)?

yes

WHAT PART (INITIAL, FINAL, STEP)?

1,120,12

PREDICTED VS. ACTUAL RESULTS:

OB. NO.	ACTUAL	PREDICTED	%DEVIATION
1	.385775+01	.377441+01	2.16
13	.321840+01	.317747+01	1.27
25	.337288+01	.336292+01	.30
37	.342785+01	.347028+01	-1.24
49	.432563+01	.437717+01	-1.19
61	.344014+01	.348335+01	-1.26
73	.400280+01	.399166+01	.28
85	.357452+01	.357611+01	-.04
97	.464195+01	.463681+01	.11
109	.479612+01	.476218+01	.71

DO YOU WANT THE RESIDUALS STORED (YES/NO)?

yes

OUTPUT DATA FORMAT?

(4e15.8)

SERIES STORED.

LSR TERMINATES.

→ @save lsra, rl

We have not printed out enough of the deviations of predicted from actual values to decide if the residuals are close to being white. However, this can be determined by submitting the residuals, saved under the name rl, to ACF and PACF:

→ @acf,n

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

cor

LENGTH OF SERIES?

123

NUMBER OF LAGS (ZERO INCLUDED)?

21

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add r1

0	.10000000+01	7	.53026889+00	14	.30409733+00
1	.91360913+00	8	.58674648+00	15	.27090824+00
2	.86974473+00	9	.53077113+00	16	.24346690+00
3	.82899847+00	10	.48667117+00	17	.21895623+00
4	.77865961+00	11	.45664223+00	18	.18133523+00
5	.72503306+00	12	.41310194+00	19	.16843886+00
6	.66401155+00	13	.35039130+00	20	.14462271+00

VARIANCE= .10740904-02

MEAN= -.14518410-06

DO YOU WANT THE COVARIANCES STORED (YES/NO)?

yes

COVARIANCE STORED.

DO YOU WANT COVARIANCE (COV), CORRELATION (COR) OR END?

end

ACF TERMINATES.

→ @pacf

PACF COMPUTES THE PARTIAL AUTO-CORRELATION AND A.R. COEFFICIENTS
UP TO ORDER K TOGETHER WITH THE RESIDUAL VARIANCES OF THE
FITTED A.R.'S UP TO ORDER K AND THE FIRST ORDER M.A. COEFFICIENTS.

MAXIMUM ORDER OF K?

15

PACF:

1	.91360912+00	6	-.99956975-01	11	.72968422-01
2	.21209436+00	7	.10971080+00	12	-.60200907-01
3	.57967539-01	8	-.56858845-02	13	-.15911209+00
4	-.57376178-01	9	-.99147042-01	14	-.18779177-01
5	-.71001749-01	10	-.14166919-01		

DO YOU WANT RESIDUAL VARIANCES (YES/NO)?

yes

RESIDUAL VARIANCES:

1	.18052634-03	6	.17648832-03	11	.18078887-03
2	.17389055-03	7	.17607510-03	12	.18216872-03
3	.17483730-03	8	.17784500-03	13	.17962297-03
4	.17584129-03	9	.17792252-03	14	.18171295-03
5	.17658256-03	10	.17978376-03		

ORDER OF A.R. PROCESS TO BE VIEWED (0=NONE OR NO MORE)?

2

.71983778+00 .21209436+00

ORDER OF A.R. PROCESS TO BE VIEWED (0=NONE OR NO MORE)?

0

DO YOU WANT THE FIRST ORDER M.A. COEFFICIENTS (YES/NO)?

no

PACF TERMINATES.

Because the acf attenuates, the pacf appears to truncate⁽¹⁾ at the 2nd lag and the 2nd residual variance is minimum for a 2nd order a.r. model, it is reasonable to examine the hypothesis that the residuals r_1 satisfy the following 2nd order a.r. model:

$$\epsilon(t) = r_1(t) - .7198r_1(t-1) - .2121r_1(t-2)$$

for $t=3,4,\dots,123$.

The construction of $\epsilon(t)$ allows us to illustrate the use of the "length of series to be used", "lag", and "scale" transformations in FILTER together with the series subtraction operator in COMB. (Of course, once it is noticed that the residuals, r_1 , are auto-correlated the regression of x_1 onto y_1 and $\text{time}123$ must be re-examined along the lines suggested in Durbin [5] or Hannan [10].)

➔ @filter,nLENGTH OF SERIES TO BE READ IN?123INPUT DATA FORMAT?(4e15.8)INPUT DATA:@add r1LENGTH OF SERIES TO BE USED?123

(1) Under the hypothesis that the process is a p^{th} order autoregression the k^{th} value of the pacf has a normal distribution with mean zero and standard deviation equal to $1/\sqrt{N}$, where the N is the length of the series. In this particular example, the two standard deviation band for significance is $\pm .18$.

MEAN= -.14518410-06
LENGTH= 123

FILTER?

lag

NUMBER OF LAGS?

2

MEAN= -.12660986-02
LENGTH= 121

FILTER?

end

DO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?

no

DO YOU WANT THE FINAL SERIES STORED (YES/NO)?

yes

OUTPUT DATA FORMAT?

(4e15.8)

SERIES STORED.

FILTER TERMINATES.

→ @save filter, rll

@filter, n

LENGTH OF SERIES TO BE READ IN?

123

INPUT DATA FORMAT?

(4e15.8)

INPUT DATA:

@add rl

LENGTH OF SERIES TO BE USED?

122

MEAN= -.42588965-03
LENGTH= 122

FILTER?

lag

NUMBER OF LAGS?

1

MEAN= -.11181355-02
LENGTH= 121

FILTER?

scale

SCALE OPERATOR (ADD/MPY)?

mpy

SCALE FACTOR?

.7198

MEAN= -.80483410-03
LENGTH= 121

FILTER?

endDO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?noDO YOU WANT THE FINAL SERIES STORED (YES/NO)?yesOUTPUT DATA FORMAT?(4e15.8)SERIES STORED.FILTER TERMINATES.→ @save filter, r12→ @filter, nLENGTH OF SERIES TO BE READ IN?123INPUT DATA FORMAT?(4e15.8)INPUT DATA:@add r1LENGTH OF SERIES TO BE USED?121MEAN= -.16543380-03LENGTH= 121

FILTER?

scaleSCALE OPERATOR (ADD/MPY)?mpySCALE FACTOR?.2121MEAN= -.16543380-03LENGTH= 121

FILTER?

endDO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?noDO YOU WANT THE FINAL SERIES STORED (YES/NO)?yesOUTPUT DATA FORMAT?(4e15.8)SERIES STORED.FILTER TERMINATES.→ @save filter, r13

The COMB program is now employed to subtract the series r12 and r13 from r11 to form e1.

```

→ @comb,n
  LENGTH OF SERIES 1 TO BE READ IN?
  121
  INPUT DATA 1 FORMAT?
  (4e15.8)
  INPUT DATA 1 :
  @add r11
  LENGTH OF SERIES 2 TO BE READ IN?
  121
  INPUT DATA 2 FORMAT?
  (4e15.8)
  INPUT DATA 2 :
  @add r12
  LENGTH OF OUTPUT SERIES?
  121
  OPERATOR TO BE USED?
  sub
  DO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?
  no
  DO YOU WANT THE RESULTANT SERIES STORED (YES/NO)?
  yes
  OUTPUT DATA FORMAT?
  (4e15.8)
  SERIES STORED.
  COMB TERMINATES.
→ @save comb, k1
→ @comb,n
  LENGTH OF SERIES 1 TO BE READ IN?
  121
  INPUT DATA 1 FORMAT?
  (4e15.8)
  INPUT DATA 1 :
  @add k1
  LENGTH OF SERIES 2 TO BE READ IN?
  121
  INPUT DATA 2 FORMAT?
  (4e15.8)
  INPUT DATA 2 :
  @add r13
  LENGTH OF OUTPUT SERIES?
  121
  OPERATOR TO BE USED?
  sub
  DO YOU WANT TO SEE PART OF THE SERIES (YES/NO)?
  no
  DO YOU WANT THE RESULTANT SERIES STORED (YES/NO)?
  yes
  OUTPUT DATA FORMAT?
  (4e15.8)
  SERIES STORED.
  COMB TERMINATES.
→ @save comb, e1

```

→ @pacf,n

MAXIMUM ORDER OF K?

10

PACF:

1	-.85908396-01	4	.12719820+00	7	.14001438+00
2	-.24426123-01	5	.31113816-01	8	.59418262-01
3	.12837213+00	6	-.12368082+00	9	.17003972-01

DO YOU WANT RESIDUAL VARIANCES (YES/NO)?

no

ORDER OF A.R. PROCESS TO BE VIEWED (0=NONE OR NO MORE)?

0

DO YOU WANT THE FIRST ORDER M.A. COEFFICIENTS (YES/NO)?

yes

FIRST ORDER M.A. COEFFICIENTS:

1	-.92659724-01	4	.12719820+00	7	-.14001438+00
2	-.92405158-01	5	.31113816-01	8	.59418262-01
3	-.77088748-01	6	-.12368082+00	9	.17003972-01

→ @asf,n

DATA SPACING?

1.

WINDOW TO BE USED (TUKEY/DANIELL)?

tukey

BANDWIDTH PARAMETER?

10

NUMBER OF FREQUENCY POINTS TO BE VIEWED?

24

DO YOU WANT CONFIDENCE LIMITS (YES/NO)?

yes

DO YOU WANT FREQUENCY (FREQ.) OR PERIOD (PERIOD) DISPLAYED?

freq.

AUTO-SPECTRUM:

FREQ.	SPECTRUM
.0000	.10650-03
.0217	.10318-03
.0435	.94606-04
.0652	.83922-04
.0870	.74053-04
.1087	.66422-04
.1304	.61409-04
.1522	.58782-04
.1739	.63310-04
.1957	.73549-04
.2174	.89675-04
.2391	.10746-03
.2609	.12082-03
.2826	.12535-03
.3043	.12115-03
.3261	.11286-03
.3478	.10652-03
.3696	.10551-03
.3913	.10848-03
.4130	.11091-03
.4348	.10888-03
.4565	.10228-03
.4783	.94936-04
.5000	.91759-04

THE 90% CONFIDENCE LIMITS FOR NU=36 are: CU= 1.54095 , CL= .70309

THE SQRT OF VARIANCE RATIO IS: 24.896 %

DO YOU WANT THE SPECTRUM STORED (YES/NO)?

no

DO YOU HAVE ANOTHER SERIES (YES/NO)?

no

ASF TERMINATES.

The final example involves an application of the second LSR program, LSRP:

→ @lsrp

LSRP IS A STEPWISE MULTIPLE REGRESSION PROGRAM WITH PREDICTIONS.

THE PREDICTION RESULTS ARE STORED (IF DESIRED) ON UNIT 8.

NUMBER OF OBSERVATIONS?

7

NUMBER OF VARIABLES (DEPENDENT AND INDEPENDENT)?

2

F LEVEL?

3.25

DEPENDENT VARIABLE FORMAT?

(e20.10)

DEPENDENT VARIABLE DATA:

@add q35log

INDEPENDENT VARIABLE 1 FORMAT?

(e20.10)

INDEPENDENT VARIABLE 1 DATA:

@add gra.time

T-VALUE FOR NU= 5 DEGREES OF FREEDOM?

2.015

STANDARD ERROR OF Y .0108512

VARIABLE	COEFFICIENT	S.D.	UPPER T	LOWER T
(0=CONST.)				

0	.76394+01	.91710-02	.76579+01	.76209+01
---	-----------	-----------	-----------	-----------

1	.34170-01	.20507-02	.38302-01	.30038-01
---	-----------	-----------	-----------	-----------

PREDICTION DATA:

NUMBER OF PREDICTION VALUES?

17

INDEPENDENT VARIABLE 1 FORMAT?

(e20.10)

INDEPENDENT VARIABLE 1 DATA:

@add gra.time17

PREDICTED VALUES:

NUMBER	PREDICTION	UPPER T	LOWER T
1	.7673548+01	.7700006+01	.7647089+01
2	.7707718+01	.7732510+01	.7682925+01
3	.7741888+01	.7765625+01	.7718150+01
4	.7776058+01	.7799432+01	.7752683+01
5	.7810228+01	.7833965+01	.7786490+01
6	.7844398+01	.7869190+01	.7819605+01
7	.7878568+01	.7905026+01	.7852109+01
8	.7912738+01	.7941366+01	.7884109+01
9	.7946908+01	.7978105+01	.7915711+01
10	.7981078+01	.8015152+01	.7947003+01
11	.8015248+01	.8052437+01	.7978059+01
12	.8049418+01	.8089904+01	.8008931+01
13	.8083588+01	.8127513+01	.8039663+01
14	.8117758+01	.8165232+01	.8070283+01
15	.8151928+01	.8203039+01	.8100816+01
16	.8186098+01	.8240917+01	.8131279+01
17	.8221268+01	.8278851+01	.8161685+01

DO YOU WANT THE PREDICTION VALUES AND LIMITS SAVED (YES/NO)?

yes

OUTPUT FORMAT?

(e20.10)

SERIES STORED IN FOLLOWING ORDER:

PREDICTION SERIES, LOWER LIMIT SERIES, UPPER LIMIT SERIES.

LSRP TERMINATES.

→ @save lsrp, pul

4.0 PROGRAM TECHNIQUES AND FLOW CHARTS

The programs are designed to operate in an interactive mode for user ease and convenience. The system, TSAP, is a set of individual main programs to allow interaction with system processors, e.g., FURPUR or MATH, without the need to exit TSAP. This also allows the user to devise similar programs to be used in conjunction with TSAP, e.g., tape I/O or unpacking data. Data output at the terminal is kept minimal since terminal I/O is so much slower than printer I/O.

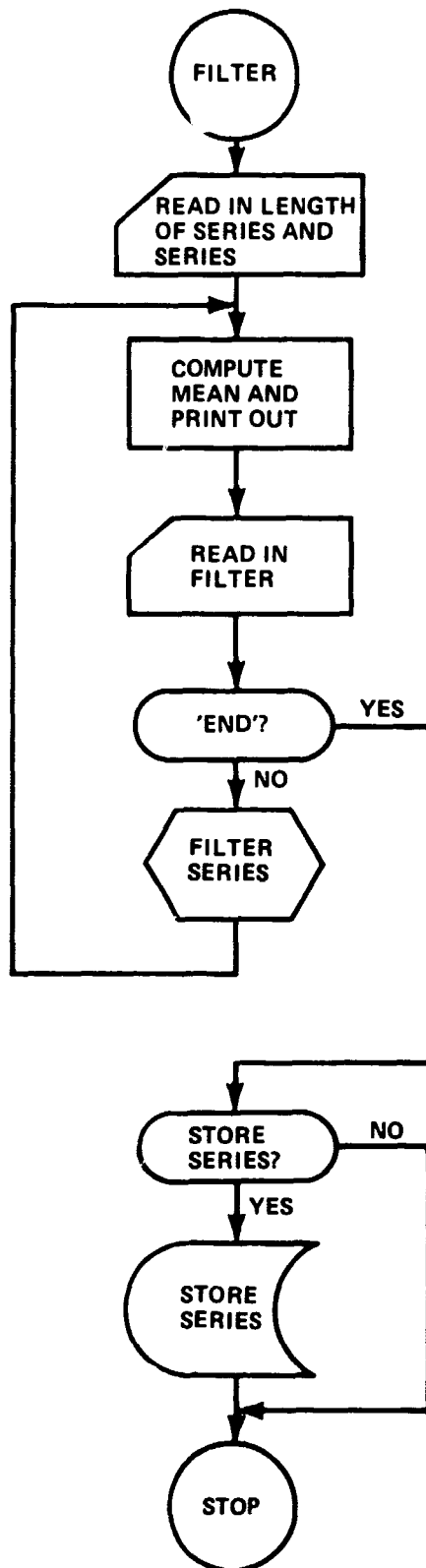
Intermediate results of interdependent programs are stored in binary on dynamically assigned FASTRAND files 1, 2 and 8 to save redundant calculations and/or I/O. Two such "linked" programs are ACF and PACF (PACF needs the covariances generated by ACF). This also prevents errors in answering the same questions in both programs.

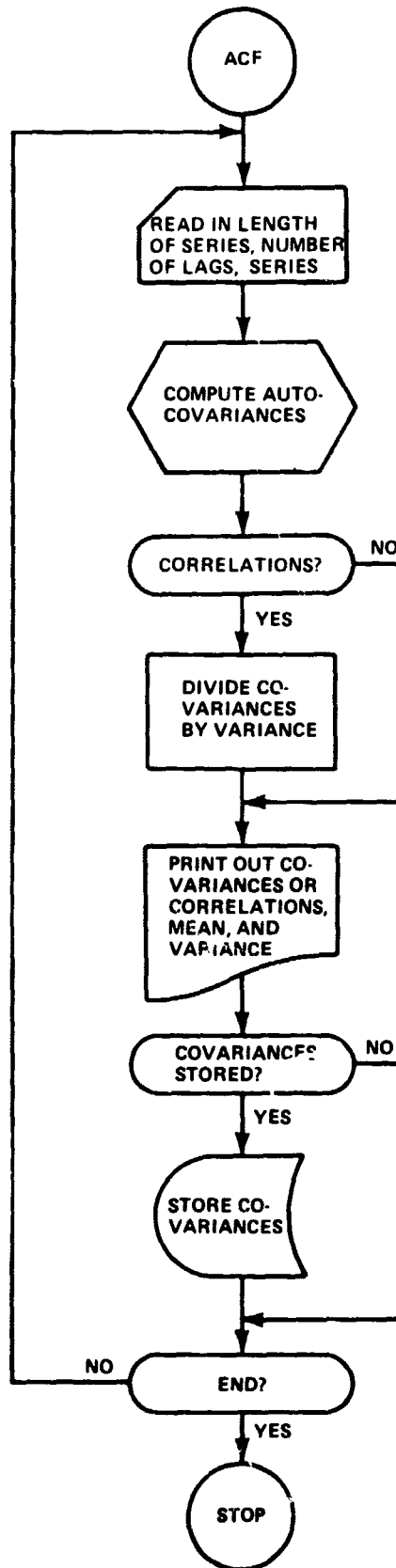
At Bellcomm, terminal core is restricted so a maximum series length of 1000 is built into all programs. This length is more of a "practical computation" size than an upper core limit and may be changed fairly easily. LSR is presently restricted to 5 series of length 500, again changeable.

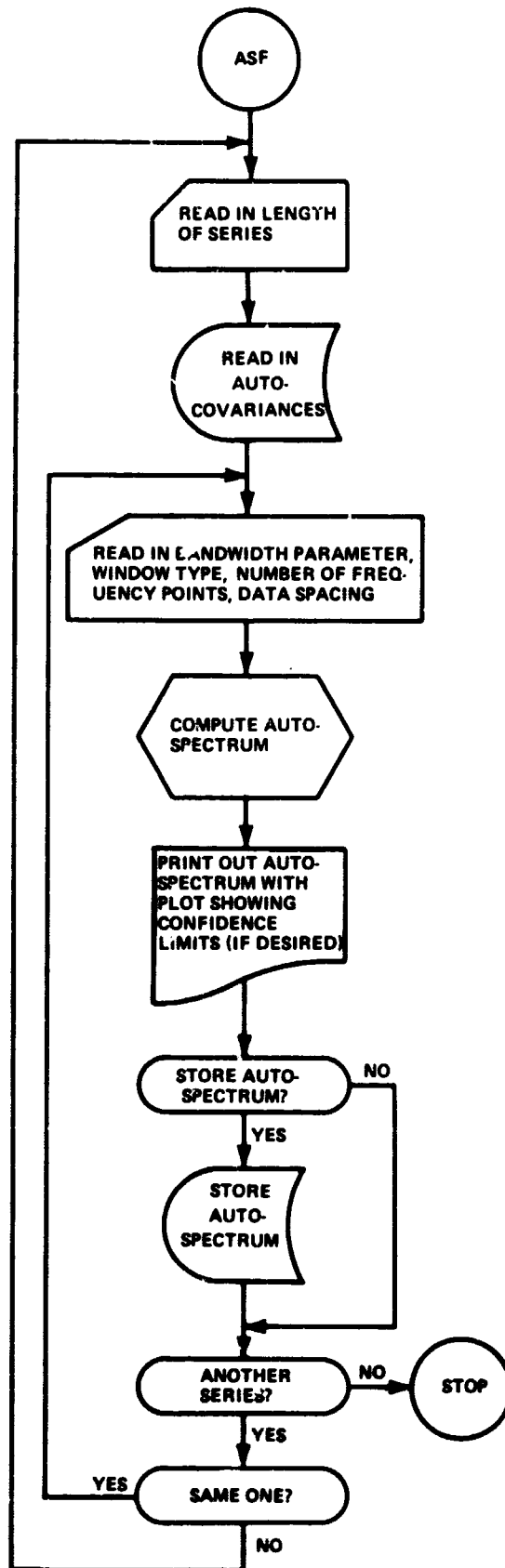
An N option is available on most of the programs to skip the introductory commentary for the experienced user.

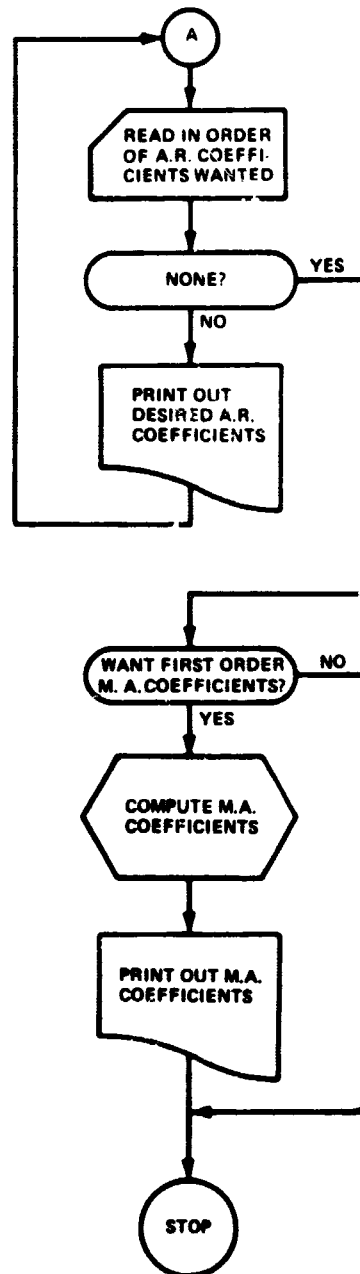
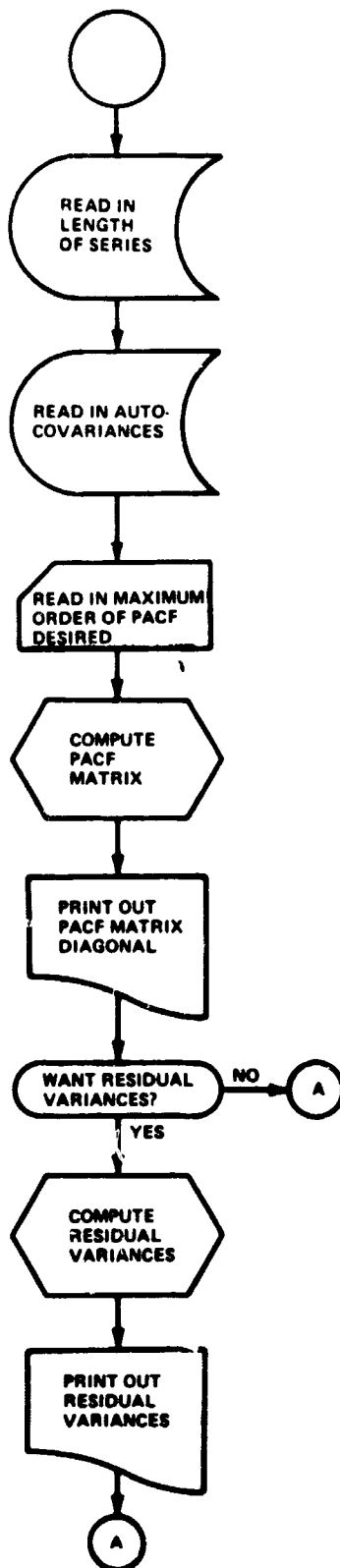
In ASF, the confidence limits use 90% chi square tables for $\gamma \leq 60$ degrees of freedom. Exceeding this limit may cause problems which can best be avoided by not asking for confidence limits for such series. The on-line plots of ASF (and XSF) consist of a 50 x NQ (NQ = number of frequency points to be viewed) grid which may cause distortion problems. It also makes comparisons between different series more difficult. XSF plots only the coherence (\tanh^{-1}) and phase to retain terminal efficiency while giving the most pertinent data output. These problems will be removed if a CRT display is incorporated into the system.

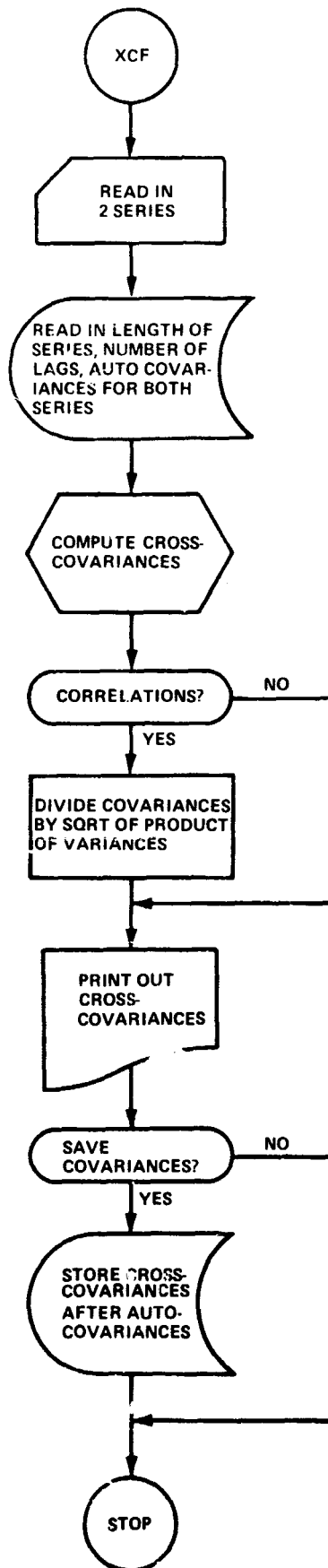
Flow charts of the main programs follow.

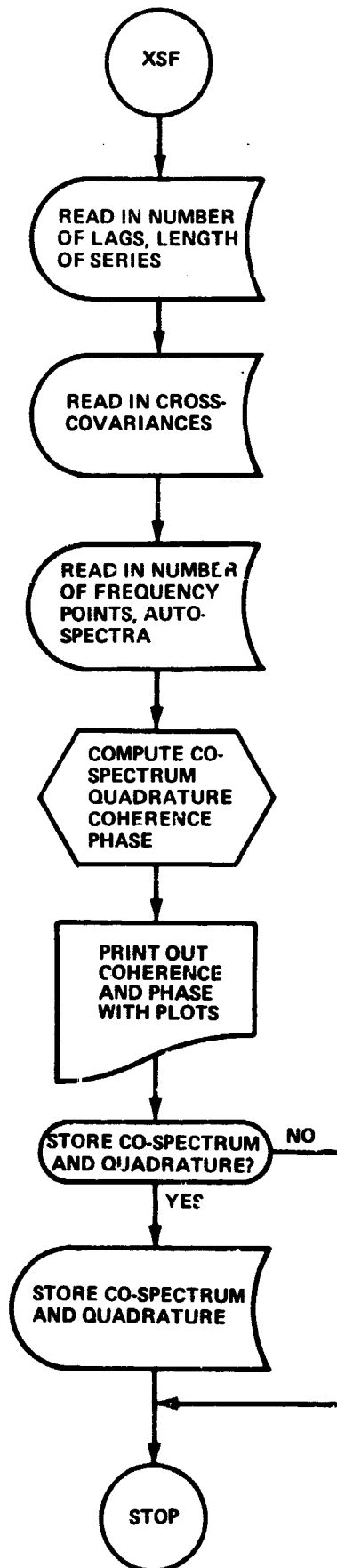


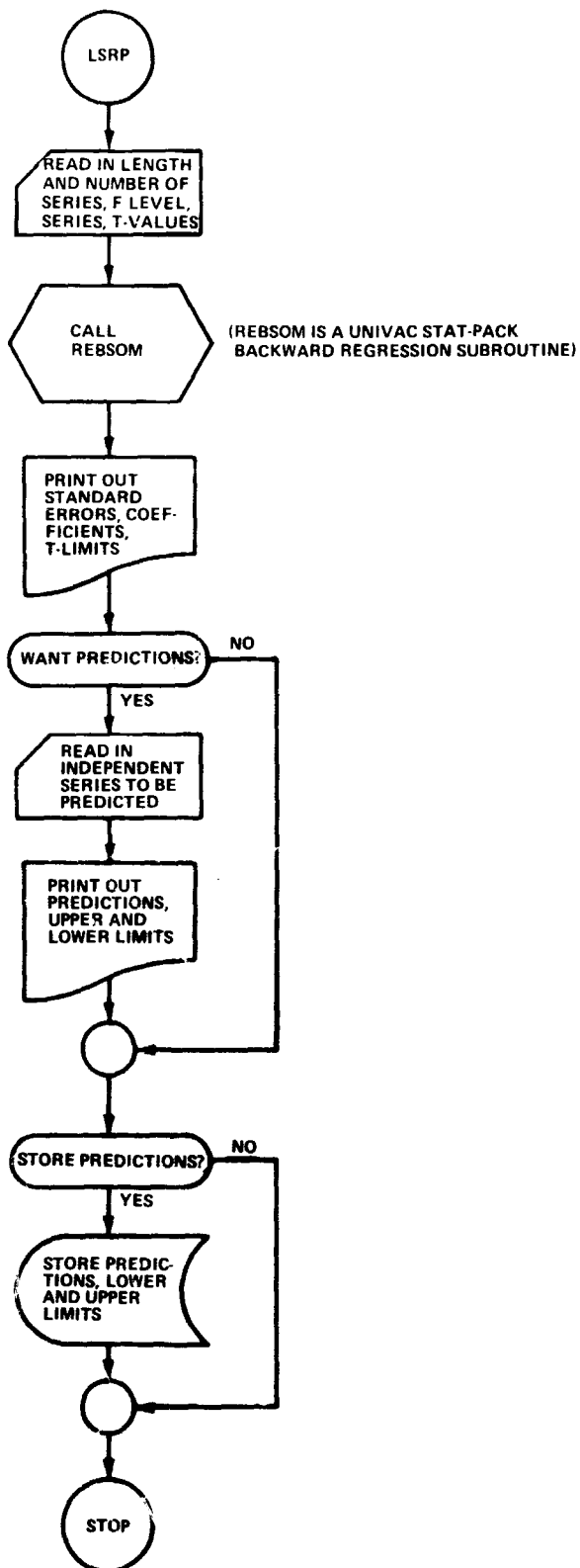


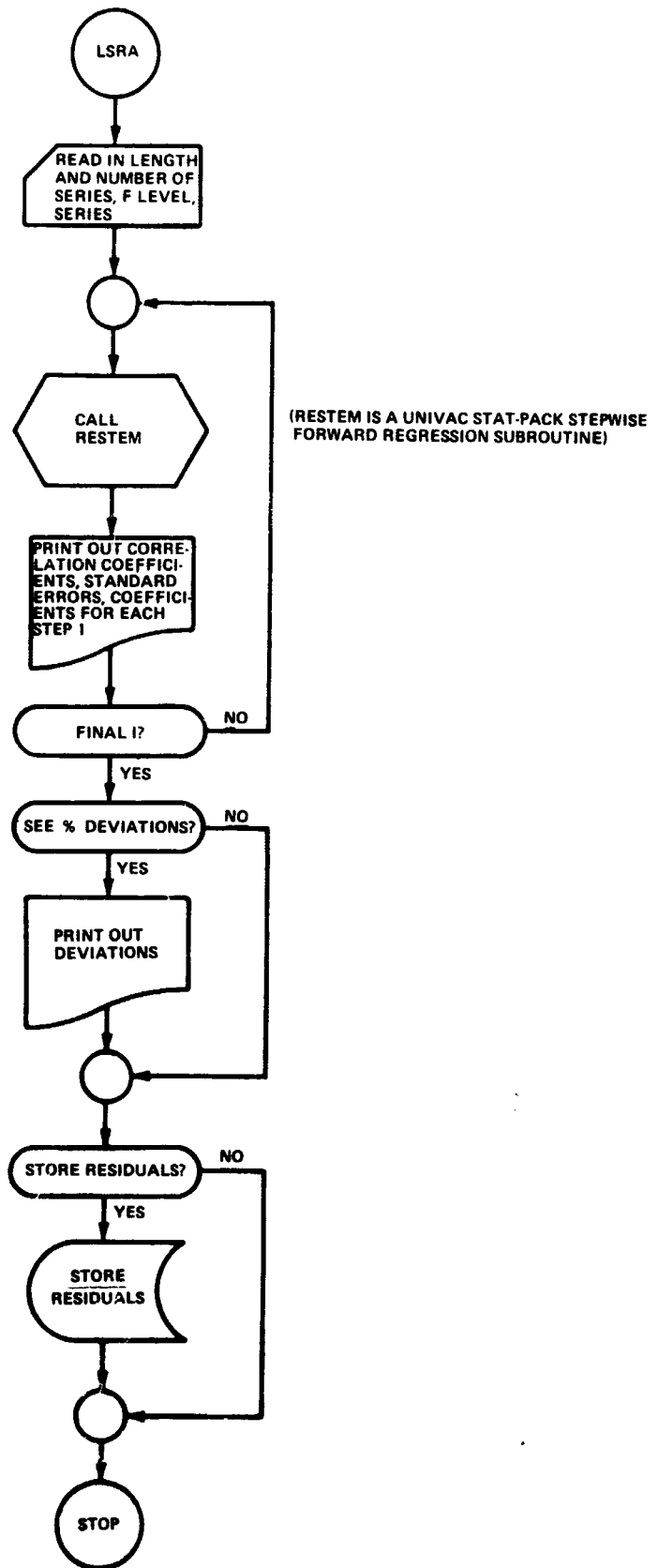


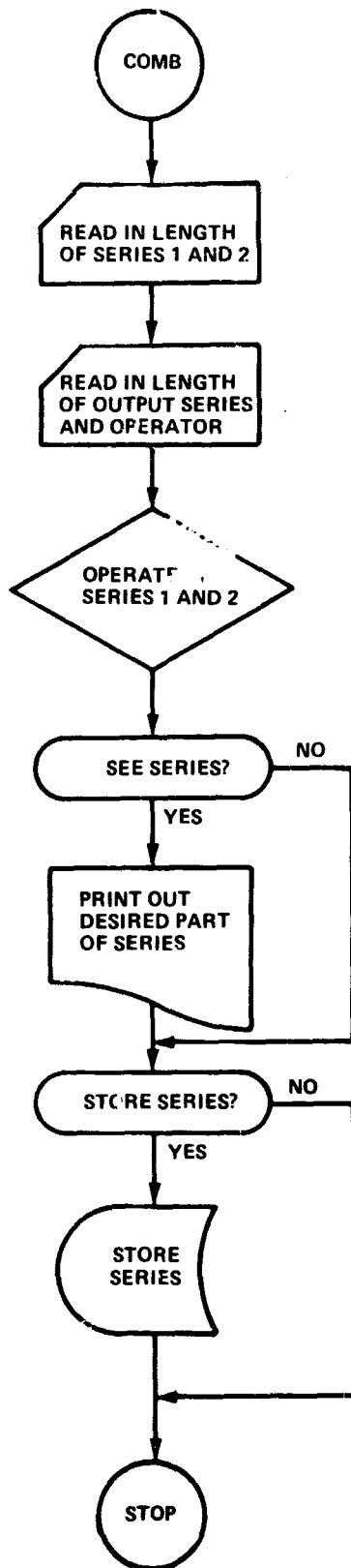












SUMMARY

The original TSAP system was developed to aid in the study of electron flux data from the earth's outer trapped radiation belts. Since then it has been applied to a variety of time series problems and each of these problems has influenced its present form. As noted in the introduction, the present content of TSAP will be increased in accordance with the needs of future applications.

The principal feature of TSAP is the fact that it is a terminal system. Time series analysis is ideally suited to such a mode of operation because it requires relatively long sequences of statistical computations which ordinarily depend directly either on the previous computations or on statistical judgements derived from these computations.

Simply stated, TSAP allows real time statistical judgements to be made in time series analysis on direction of the analysis. The versatility of TSAP is enhanced by its capability of interacting with machine processors and user designed terminal programs.



G. R. Andersen



R. R. Singers

1031-GRA-jf
RRSAttachments
Appendices I - III
References

APPENDIX I.

The stochastic properties of stationary stochastic processes are well known and are concisely presented in U. Grenander and M. Rosenblatt [8]. A recent practical approach to the subject may be found in the book by G. Jenkins and D. Watts [12]. The definitive text in the area of multiple time series analysis is the work by E. J. Hannan⁽¹⁾.

A.1 Spectral Analysis (ACF, ASF, XCF, XSF):

Let $\{X_j(t)\}$, $j=1,2$, and $t=1,2,\dots,N$, be finite realizations of two jointly stationary stochastic processes. These time series may be realizations of discrete processes or discrete series formed by sampling a realization, $\xi_j(t)$, of a continuous time stochastic process at equidistant time points, $t \cdot \Delta$, ($\Delta > 0$), and defining $X_j(t) = \xi_j(t \cdot \Delta)$, $t=1,\dots,N$.

In either case, let the centered series be denoted by

$$\tilde{X}_j(t) = X_j(t) - \bar{X}_j \quad (1)$$

where

$$\bar{X}_j = \frac{1}{N} \sum_{t=1}^N X_j(t), \quad (j=1,2) \quad (2)$$

and form the lagged (sample) cross covariance, C_{jk} , by setting

$$C_{jk}(v) = \frac{1}{N} \sum_{d=1}^{N-v} \tilde{X}_j(d) \tilde{X}_k(d+v), \quad (3)$$

⁽¹⁾ Hannan's book will be published by J. Wiley and Sons late in 1970.

for $v=0,1,\dots,N-1$ and extend this definition to $-1,\dots,-N+1$ by setting

$$C_{jk}(-v) = C_{kj}(v) \quad . \quad (4)$$

In an attempt to be consistent with most mathematical treatments of stationary stochastic processes, we will introduce the basic computational definitions concerning spectra for a unit sampling interval and consider frequency to have the dimensions of radians per unit of time. It is then a simple matter to transform the spectral estimators to the more practical form used in the programs where the data spacing is an arbitrary positive constant, Δ , and frequency is in terms of cycles per unit time.

The sample auto-spectrum, \hat{g}_{jj} , of the j^{th} time series is defined in terms of the sample auto-covariance function, C_{jj} , and a lag window, ω , by setting

$$\begin{aligned} \hat{g}_{jj}(\lambda) &= \hat{g}_{jj}(\lambda; \omega) = \\ &= \frac{1}{2\pi} (C_{jj}(0) + 2 \sum_{v=1}^{N-1} \omega\left(\frac{v}{M}\right) C_{jj}(v) \cos(\lambda v)) \quad , \end{aligned} \quad (5)$$

where $|\lambda| \leq \pi$. The positive integer M , the bandwidth parameter, determines the bandwidth of the spectral window with Fourier coefficients $\omega\left(\frac{v}{M}\right) = \omega\left(\frac{-v}{M}\right)$, $v=0,1,\dots,N-1$.

Two types of spectral windows are available in TSAP: the Tukey window and the Daniell window. The lag windows corresponding to these spectral windows are as follows:

(i) Tukey:

$$\omega(y) = \omega_T(y) = \begin{cases} \frac{1}{2} (1 + \cos(\pi y)), & |y| \leq 1 \\ 0, & |y| > 1 \end{cases}$$

(ii) Daniell:

$$\omega(y) = \omega_D(y) = \begin{cases} \frac{\sin \pi y}{\pi y}, & y \neq 0 \\ 1, & y = 0. \end{cases}$$

The use of the Tukey window in (5) requires that only M lagged covariances (including the variance) be calculated; whereas, using the Daniell window requires all lagged covariances that can be calculated from a series of length N , namely N (including zero). For this reason the Daniell window should only be used on relatively short series (say, $N \leq 500$).

If we denote the spectral window corresponding to $\omega(\frac{\cdot}{M})$ by W_M , then

$$W_M(s) = \frac{1}{2\pi} \sum_{-N+1}^{N-1} \omega\left(\frac{v}{M}\right) e^{ivs}, \quad (6)$$

$$|s| \leq \pi.$$

Although the reader should consult any one of the above mentioned references for details on spectral analysis (cf. the bibliography for additional works), we will indicate the relationship between the spectral window and \hat{g}_{jj} .

If we set ω identically equal to 1 in (5) we obtain the (continuous) periodogram $\hat{g}_{jj}(\lambda; 1)$. Integrating the product $W_M(\lambda - s) \hat{g}_{jj}(s; 1)$ with respect to s over the interval $(-\pi, \pi)$ we obtain

$$\hat{g}_{jj}(\lambda; \omega) = \int_{-\pi}^{\pi} W_M(\lambda-s) \hat{g}_{jj}(s; 1) ds, \quad (7)$$

$|\lambda| \leq \pi$. This exhibits the sample auto-spectrum as a weighted average of the periodogram. With the Daniell window this averaging is approximately uniform over the interval $(\lambda-h, \lambda+h)$ where $h = \pi/M$. The relationship between the sample auto-spectrum formed with the Tukey window and the periodogram is more easily seen directly from (5) where a simple cosine identity leads to

$$\hat{g}_{jj}(\lambda_k; \omega_T) = \begin{cases} \frac{1}{4}\hat{g}_{jj}(\lambda_{k-1}; 1) + \frac{1}{2}\hat{g}_{jj}(\lambda_k; 1) + \frac{1}{4}\hat{g}_{jj}(\lambda_{k+1}; 1) & \text{for } k=1, 2, \dots, Q-1 \\ \frac{1}{2}\hat{g}_{jj}(0; 1) + \frac{1}{4}\hat{g}_{jj}(\lambda_1; 1) & \text{for } k=0 \\ \frac{1}{2}\hat{g}_{jj}(\pi; 1) + \frac{1}{4}\hat{g}_{jj}(\lambda_{Q-1}; 1) & \text{for } k=Q \end{cases} \quad (8)$$

where $\lambda_k = \pi k/Q$, $k=0, 1, \dots, Q$.

Since $\hat{g}_{jj}(\cdot; 1)$ is proportional to the modulus squared of the discrete Fourier transform of the time series, (8) is often used for computation when a fast Fourier transform (FFT) is available. The first extension of TSAP will include a FFT routine for use in model estimation. At that time either (8) will be used or, following Gentleman and Sande [6], (5) will be used with the lagged covariances calculated using the FFT and the convolution theorem.

If the time series $\{X_j(t)\}$, $t = 1, 2, \dots, N$, is related to a finite realization of $\xi_j(\tau)$, $0 < \tau \leq T$, of a stationary process by $X_j(t) = \xi_j(\Delta t)$, $\Delta > 0$, $N\Delta \leq T$, then the right-hand side of (5), multiplied by Δ and taking λ in $(-\pi/\Delta, \pi/\Delta)$, defines an estimate (call it $g_j^*(\lambda)$) of

$$g_j(\lambda) = \sum_{r=-\infty}^{+\infty} \phi_j\left(\lambda + \frac{2\pi r}{\Delta}\right), \quad |\lambda| < \pi/\Delta,$$

where ϕ_j is the spectrum of ξ_j .

Hence, g_j will be approximately equal to ϕ_j only if Δ is chosen in such a way that $\phi_j(s) \approx 0$ for $|s| > \frac{\pi}{\Delta}$, the so-called Nyquist frequency (cf., R. B. Blackman and J. W. Tukey [3]). Then

$$\phi_j(\lambda) \approx \begin{cases} g_j(\lambda) & , \quad |\lambda| \leq \pi/\Delta \\ 0 & , \quad |\lambda| > \pi/\Delta \end{cases}$$

and $g_j^*(\lambda)$, $|\lambda| \leq \pi/\Delta$ is an estimate of the spectrum of ξ_j .

We now state the computational forms used in TSAP, allowing for data spacing, Δ , and requiring that frequency be in dimensions of cycles per unit time⁽¹⁾:

$$\hat{f}_{jj}(\lambda_k) = \Delta(C_{jj}(0) + 2 \sum_{v=1}^{M-1} \omega_T(\frac{v}{M}) C_{jj}(v) \cos(\frac{\pi k v}{M_1})) , \quad (10)$$

where $\lambda_k = \frac{k}{2M_1\Delta}$ ⁽²⁾, $k=0,1,\dots,M_1$. M_1 is selected by the user and is generally between M and $2M$. The proper bandwidth parameter, M , depends on the unknown spectrum and is usually found (if possible) by the technique of "window closing" (cf., [12]). Taking M to be 5, 10 and 20% of the record length N is a reasonable rule of thumb.

A compromise must usually be made between resolution and accuracy. As a guide to the accuracy of the estimate, the square root of the variance ratio, $\text{var}(\hat{f}_{jj}(\lambda)/f_{jj}(\lambda))$, is printed out at the end of ASF. This quantity is $(3/4)(M/N)$ for the Tukey window and M/N for the Daniell window. The user also has the option of having 90% confidence limits plotted with the sample auto-spectrum. These are the usual limits based on the approximation which states that $v \cdot \hat{f}_{jj}(\lambda)/f_{jj}(\lambda)$, where f_{jj} denotes the true (but unknown) auto-spectrum, is a chi-square random variable with v degrees of freedom, with $v = (8/3)(N/M)$ in the case of the Tukey window and $v = 2 N/M$ for the Daniell window. (Cf., Grenander and Rosenblatt [8].)

(1) For simplicity we will state them for the Tukey window only since this is all that is available in the cross-spectral segment of TSAP.

(2) The user may choose to plot f_{jj} against period, λ_k^{-1} , $k=1,2,\dots,M_1$.

The sample co-spectrum and quadrature spectrum of $\{X_j(t)\}$ and $\{X_k(t)\}$ are computed by

$$\hat{p}_{jk}(\lambda_\ell) = \Delta \{C_{jk}(0) + \sum_{v=1}^{M-1} (C_{jk}(v) + C_{kj}(v)) \omega_T(\frac{v}{M}) \cos(\frac{\pi \ell v}{M_1})\} \quad (11)$$

and

$$\hat{q}_{jk}(\lambda_\ell) = \Delta \sum_{v=1}^{M-1} (C_{jk}(v) - C_{kj}(v)) \omega_T(\frac{v}{M}) \sin(\frac{\pi \ell v}{M_1}) \quad (12)$$

respectively, where $\lambda_\ell = \frac{\ell}{2M_1\Delta}$, $\ell=0,1,\dots,M_1$.

These functions are used to compute the sample coherence [2]

$$\hat{\gamma}_{jk}(\lambda_\ell) = \begin{cases} \frac{\hat{p}_{jk}^2(\lambda_\ell) + \hat{q}_{jk}^2(\lambda_\ell)}{\hat{f}_{jj}(\lambda_\ell) \hat{f}_{kk}(\lambda_\ell)}, & \hat{f}_{jj}(\lambda_\ell) \cdot \hat{f}_{kk}(\lambda_\ell) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (13)$$

and the sample phase

$$\hat{\phi}_{jk}(\lambda_\ell) = \begin{cases} \tan^{-1} \left(\frac{\hat{q}_{jk}(\lambda_\ell)}{\hat{p}_{jk}(\lambda_\ell)} \right) & , \hat{p}_{jk}(\lambda_\ell) > 0 \\ \tan^{-1} \left(\frac{\hat{q}_{jk}(\lambda_\ell)}{\hat{p}_{jk}(\lambda_\ell)} \right) - \pi & , \hat{p}_{jk}(\lambda_\ell) < 0 \end{cases}$$

$\lambda_\ell = \frac{\ell}{2M_1\Delta}$, $\ell=0,1,\dots,M_1$. For definiteness the phase is set equal to $\frac{\pi}{2}$ if $\hat{p}_{jk}(\lambda_\ell) = 0$.

A.2 Auto-Regression Coefficients, Residual Variance, and Partial Auto-Correlation Function (PACF)

All estimates in this section⁽¹⁾ are based on the sample auto-correlation function $r(v) = C(v)/C(0)$, where

$$C(v) = N^{-1} \sum_{t=1}^{N-v} x_t x_{t+v}.$$

We use the results of Durbin [5]:

Letting $a_1^{(1)} = r(1)$, $V_1 = 1$, choose a positive integer $k \leq N-1$, and define $a_1^{(k)}$, $a_2^{(k)}$, ..., $a_k^{(k)}$ by setting

⁽¹⁾ We assume that the time series under discussion is $\{X(t): t=1,\dots,N\}$, with $\bar{X}=0$.

$$a_s^{(s)} = (r(s) - a_1^{(s-1)} r(s-1) - a_2^{(s-1)} r(s-2) - \dots - a_{s-1}^{(s-1)} r(1)) / v_{s-1} \quad (1)$$

where

$$v_{s-1} = 1 - a_1^{(s-1)} r(1) - \dots - a_{s-1}^{(s-1)} r(s-1) \quad (2)$$

for $s=2, \dots, k$ and

$$a_r^{(s)} = a_r^{(s-1)} - a_s^{(s)} a_{s-r}^{(s-1)}, \quad r=1, \dots, s-1. \quad (3)$$

Then $a_s^{(s)}$, $s=2, \dots, k$, are the partial correlation coefficients measuring the correlation between members of the time series $2, \dots, k$ time units apart with the linear effect of intervening observations removed. The terms $a_1^{(s)}, \dots, a_s^{(s)}$ are the least squares estimators of the autoregression coefficients in the s^{th} order a. r. model.

$$y(t) = a_1 y(t-1) + \dots + a_s y(t-s) + \epsilon(t). \quad (4)$$

The quantity

$$\sigma_\epsilon^2(s) = \frac{N-s}{N-2s-1} C(0) v_s \quad (5)$$

is an estimator of the residual variance of the model in (4), i.e., the variance of $\epsilon(t)$. v_s satisfies

$$v_s = v_{s-1} (1 - (a_s^{(s)})^2)$$

APPENDIX II

This appendix contains an explanation of the transformations available in FILTER. Let $\{X(t): t=1, \dots, N\}$ be a given time series, then a request for "center" transforms $X(t)$ into $X(t) - \bar{X}$, where \bar{X} is the sample mean (cf. Appendix I); symbolically

$$\text{Center: } X(t) \rightarrow X(t) - \bar{X}.$$

Similarly,

$$\text{Exp: } X(t) \rightarrow e^{X(t)};$$

$$\text{Log: } X(t) \rightarrow \log_e X(t), \text{ if } X(t) > 0, \text{ for all } t;$$

$$\text{Log10: } X(t) \rightarrow \log_{10} X(t), \text{ if } X(t) > 0, \text{ for all } t;$$

$$\text{Diff: } X(t) \rightarrow X(t) - X(t-1);$$

$$\text{10**: } X(t) \rightarrow 10^{X(t)}$$

$$\text{Sqrt: } X(t) \rightarrow \sqrt{X(t)}, \text{ if } X(t) \geq 0, \text{ for all } t;$$

$$\text{Abs: } X(t) \rightarrow |X(t)|;$$

$$\text{Scale: } X(t) \rightarrow \alpha X(t), \text{ where the real number } \alpha \text{ is supplied by the user.}$$

The transformation "LAG", accompanied by a user response k , $1 \leq k \leq N-1$, deletes the first k term from the series, i.e., it maps

$$(X(1), X(2), \dots, X(k), X(k+1), \dots, X(N))$$

into

$$(X(k+1), \dots, X(N))$$

When the high pass Tukey filter (A. S. Alvia and G. M. Jenkins, [1]) is requested, the following linear transformation

$$(F_T^{(m)} X)(t) = \sum_{j=-m}^m \lambda_j X(t-j), \quad (1)$$

is applied to the series $\{X(\tau): \tau=1, \dots, N\}$, where $t=m+1, \dots, N-m^{(1)}$ and $\lambda_0 = 1 - \frac{1}{m+1}$,

$$\lambda_j = \lambda_{-j} = \frac{-1}{2(m+1)} (1 + \cos(\frac{j\pi}{m+1})), \quad (j=1, 2, \dots, m).$$

The corresponding frequency response function

$A_m(\lambda) = \sum_{j=-m}^m \lambda_j \cos(\lambda_j)$ constitutes the Tukey high pass filter;

its effect on the auto-spectrum, f , of the process generating the time series $\{X(t)\}$ is well-known and given by

$f_X(\lambda) = |A_m(\lambda)|^2 f(\lambda)$. The gain $|A_m|^2$ is shown in Figure A.II.1 for $m=7$.

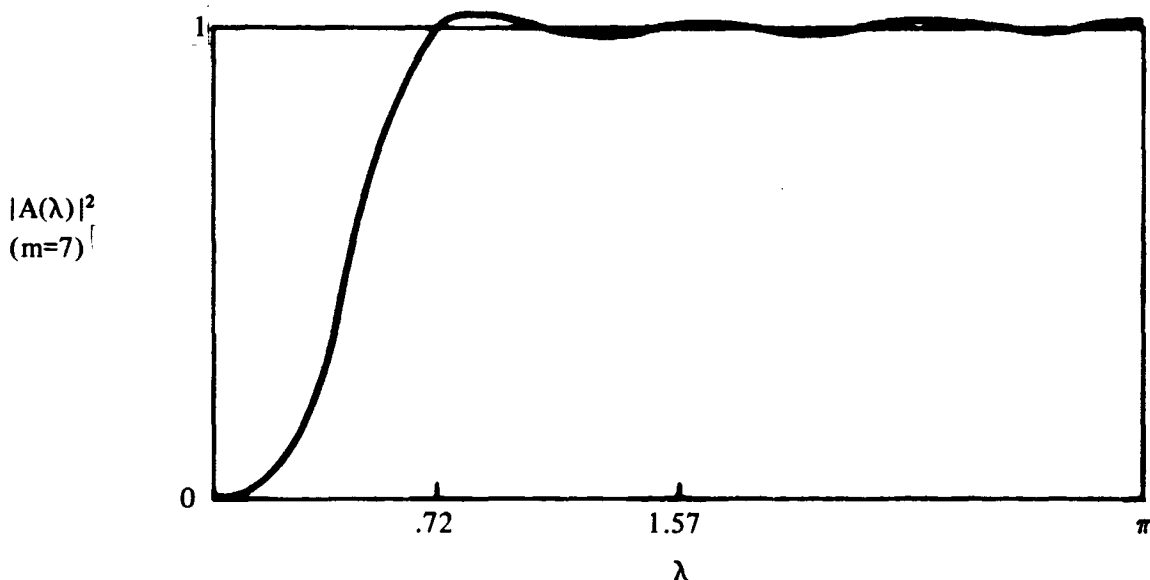


FIGURE A.II.1

(1) The length, $2m+1$, of the moving average (1) is specified by the user.

The low frequency portion of the series $X(t)$ corresponding to the low pass filter with frequency response $1 - A_m(\lambda)$ is just $X(t) - (F_T^{(m)} X)(t)$, $t=m+1, \dots, N-m$.

The Goodman band pass filter, as presented by N. R. Goodman [7] and extended in the Biomedical Computer Program [4], is a trapezoidal band pass filter constructed from a series of overlapping triangles of unit height with base length $2/m\Delta^{(1)}$, using $2m+1$ pieces of data. The high pass filter that we refer to as a Goodman high pass filter is a simple modification of Goodman's results constructed for use in TSAP.

The linear transformation of $\{X(t)\}$ which produces a bandpass filter with center frequency α_0 using n triangles (2) and $2m+1$ pieces of data is given by

$$(F_{N, \alpha_0}^{(m)} X)(t) = \sum_{j=-m}^m \beta_j X(t-j),$$

$t=m+1, \dots, N-m$, where $\beta_0 = 2n/m$,

$$\beta_j = \beta_{-j} = \frac{2}{m} [.54 + .46 \cos(\frac{j\pi}{m})] \cos(j\alpha_0) \frac{\sin(\frac{nj\pi}{m})}{\sin(\frac{j\pi}{m})}$$

$(j=1, 2, \dots, m-1)$ and

$$\beta_m = (-1)^{n+1} \frac{n}{m} (.08) \cos(m\alpha_0),$$

(1) When frequency is in dimensions of cycles per unit time and data spacing is $\Delta > 0$.

(2) See Figures A.II.2 and 3 for examples with $n=2$ and $m=3$.

provided that $(n+1)/2m\Delta \leq \alpha_0 \leq \frac{1}{2}\Delta (1 - \frac{n+1}{m})$

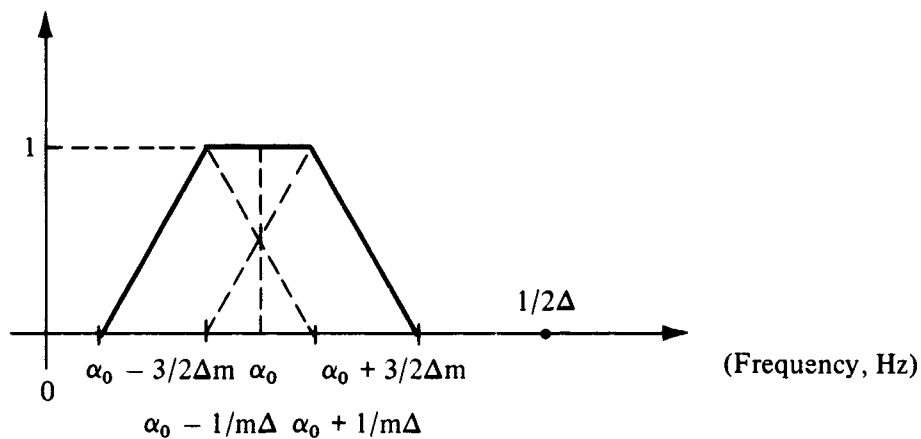


FIGURE A.II.2

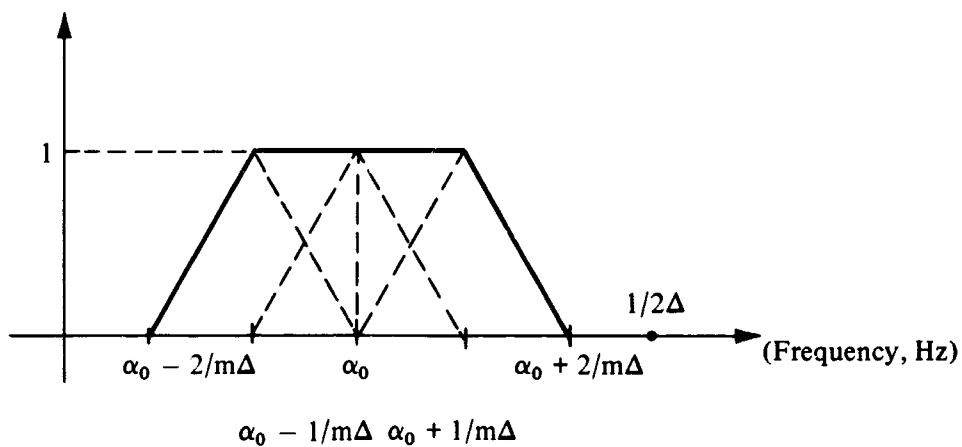


FIGURE A.II.3

The length of the base of the trapezoid is then $(n+1)/m\Delta$.

The modification of the band pass to high pass filter mentioned earlier is accomplished by observing that the Goodman filters are symmetric with respect to the origin and add if the base of the trapezoid defining the band pass filter on $(0, 1/2\Delta)$ overlaps $1/2\Delta$ (or the origin).

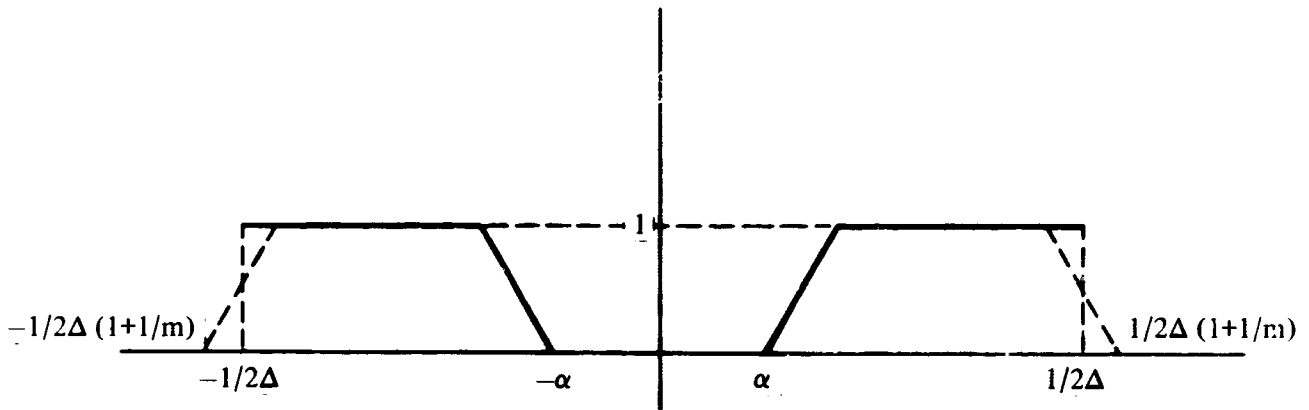


FIGURE A.II.4

The program requests the number of triangles, n , and $2m+1$ and tells the user the cut-off point:

$$\alpha = \frac{1}{2\Delta m} [m - 2n - 1] .$$

APPENDIX III

This appendix contains listings of all main programs presently implemented in TSAP except for SAVE⁽¹⁾ and MATHCON⁽¹⁾ both to be in BAPL (BELLCOMM APPLICATIONS PROGRAM LIBRARY) on SYS*BLIB along with the TSAP INDEX.

@PRT	R. INDEX	
000001	000	DATE OF PRESENT ENTRY - 12/1/70
000002	000	DATE OF LAST ENTRY - 11/30/70
000003	000	
000004	000	PRESENT CONTENTS:
000005	000	
000006	000	0) SAVE - PROGRAM TO CONVERT A FORTRAN GENERATED DATA
000007	000	FILE TO SDF(SYSTEM DATA FORMAT) ELEMENT FILE.
000008	000	1) FILTER* - PROGRAM TO FILTER OR TRANSFORM A DATA SERIES.
000009	000	2) ACF - AUTO-COVARIANCE/CORRELATION PROGRAM.
000010	000	3) PACF - PARTIAL AUTO-CORRELATION PROGRAM.
000011	000	4) ASF* - AUTO-SPECTRUM PROGRAM.
000012	000	5) LSRA - LEAST SQUARES MULTIPLE REGRESSION PROGRAM
000013	000	WITH AN ANALYSIS OF VARIANCE PRINT OUT.
000014	000	6) XCF - CROSS-COVARIANCE/CORRELATION PROGRAM.
000015	000	7) XSF* - CROSS-SPECTRUM PROGRAM.
000016	000	8) COMB - PROGRAM TO COMBINE TWO TIME SERIES.
000017	000	9) MATHCON* - PROGRAM TO CONVERT MATH DATA SERIES TO
000018	000	FORTRAN DATA SERIES.
000019	000	10) LSRP - LEAST SQUARES MULTIPLE REGRESSION PROGRAM
000020	000	WITH PREDICTION LIMITS.
000021	000	* - REVISED ENTRY
000022	000	□ - NEW ENTRY

⁽¹⁾ Both programs were written by C. Mee.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.FILTER,JJJ

000 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:28:17.

N PROGRAM

RAGE USED: CODE(1) 001565; DATA(0) 002410; BLANK COMMON(2) 000000

ERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 CSF
 05 EXIT
 06 NINTR\$
 07 NRDU\$
 10 NI01\$
 11 NI02\$
 12 NWDU\$
 13 ALOG
 14 NEXP2\$
 15 ALOG10
 16 SQRT
 17 EXP
 20 COS
 21 NEXP1\$
 22 SIN
 23 NSTOP\$

RAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

01	000030	1L	0001	000245	10L	0000	002012	100F	0000	002065	1
00	002076	103F	0000	002103	104F	0000	002114	105F	0000	002125	1
00	002141	108F	0000	002234	109F	0000	002274	110F	0000	002300	1
00	002312	112F	0000	002321	113F	0000	002177	114F	0000	002150	1
00	002203	117F	0000	002211	118F	0000	002222	119F	0001	000264	1
00	002255	121F	0000	002324	122F	0000	002246	123F	0000	002155	1
00	002106	140F	0001	000071	142G	0001	000111	153G	0001	000325	1
01	000345	18L	0001	000132	2L	0001	000365	20L	0000	002074	2
01	000204	211G	0001	000424	22L	0001	000221	221G	0001	000235	2
01	000257	242G	0001	000614	25L	0001	000274	252G	0001	000315	2
01	000335	272G	0001	000746	28L	0001	001022	29L	0001	001270	3
01	000420	321G	0001	001440	33L	0001	000500	346G	0001	000545	3
01	001066	455G	0001	001117	463G	0001	001355	50L	0001	001531	5
01	001336	523G	0001	001554	53L	0001	001430	554G	0001	001500	5
01	001517	606G	0001	000225	8L	0000 R	001777	A	0000 R	002001	A
00 R	002005	CP	0000 R	002003	DEL	0000 R	001750	FMI	0000 R	001756	F
00 I	001773	IFL	0000 I	002000	II	0000 I	002006	ISO	0000 I	001766	I
00 I	001775	K	0000 I	001767	L	0000 I	001776	M	0000 I	001770	N
03 L	000000	OPTION	0000 R	002007	SF	0000 R	001772	SM	0000 R	002004	W

1* C

2* C TITLE

FILTER - A PROGRAM TO FILTER OR TRANSFORM A

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

DATA SERIES.

```

3*  C
4*  C
5*  C AUTHOR      R.R.SINGERS
6*  C
7*  C SPONSOR     G.R.ANDERSEN
8*  C
9*  C DATE        AUGUST,1970
10* C
11* C KEY WORDS   FILTER
12* C             TRANSFORMATION
13* C
14* C PURPOSE     TO APPLY ONE OR MORE OF A LIST OF FILTERS OR
15* C             TRANSFORMS TO A DATA SERIES.
16* C
17* C METHOD       THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
18* C             ASKING FOR CERTAIN PARAMETERS AND APPLYING THEM TO
19* C             THE INPUT DATA SERIES. THE PROCESS IS SEQUENTIAL
20* C             ALLOWING MORE THAN ONE FILTER OR TRANSFORMATION
21* C             TO BE APPLIED TO THE SAME SERIES.
22* C
23* C NOTE        1) A DYNAMICALLY ASSIGNED FILE (UNIT 8) IS
24* C             USED TO STORE THE FINAL SERIES.
25* C
26*             PARAMETER MX=1000
27*             DIMENSION X(MX),FMI(6),FMO(6)
28*             DIMENSION ASGB(2)/'QASG,T 8,F'/
29*             LOGICAL OPTION
30*             READ(5,201,END=53) FMI
31*             IF(OPTION('N'))GO TO 1
32*             L=MX
33*             WRITE(6,100)
34*             100  FORMAT(/, 'FILTER' CONTAINS THE FOLLOWING FILTERS:/' C
35*             .ENTER,EXP,LOG,DIFF,10**,LOG10,SQRT,LAG,ABS,TUKEY(HIGH AND LOW PASS
36*             .),GOODMAN,/' SCALE. '/' TO TERMINATE THE FILTER SEQUENCE,REPLY WIT
37*             .H 'END'.'/ THE FINAL SERIES IS STORED ON UNIT 8(IF DESIRED).')
38*             1   WRITE(6,101)
39*             101  FORMAT(' LENGTH OF SERIES TO BE READ IN?')
40*             READ(5,200,END=53)N
41*             200  FORMAT( )
42*             IF(N.GT.MX)GO TO 51
43*             201  FORMAT(6A6)
44*             WRITE(6,103)
45*             103  FORMAT(' INPUT DATA FORMAT?')
46*             READ(5,201,END=53)FMI
47*             WRITE(6,104)
48*             104  FORMAT(' INPUT DATA:')
49*             READ(5,FMI,END=53)(X(I),I=1,N)
50*             WRITE(6,140)
51*             140  FORMAT(' LENGTH OF SERIES TO BE USED?')
52*             READ(5,200,END=53)N
53*             2    SM=0.
54*             DO 3 I=1,N
55*             3    SM=SM+X(I)
56*             SM=SM/N
57*             WRITE(6,105)SM,N
58*             105  FORMAT(' MEAN=',F15.8/' LENGTH=',I5///' FILTER?')
59*             4    READ(5,201,END=53) IFL

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

60*      IF(IFL.EQ.'END   ')*GO TO 50
61*      IF(IFL.NE.'CENTER')GO TO 6
62*      DO 5 I=1,N
63*      5   X(I)=X(I)-SM
64*      GO TO 2
65*      6   IF(IFL.NE.'ABS   ')*GO TO 8
66*      DO 7 I=1,N
67*      7   X(I)=ABS(X(I))
68*      GO TO 2
69*      8   IF(IFL.NE.'LOG   ')*GO TO 10
70*      DO 9 I=1,N
71*      9   X(I)=ALOG(X(I))
72*      GO TO 2
73*      10  IF(IFL.NE.'DIFF  ')*GO TO 12
74*      N=N-1
75*      DO 11 I=1,N
76*      11  X(I)=X(I+1)-X(I)
77*      GO TO 2
78*      12  IF(IFL.NE.'10**  ')*GO TO 14
79*      DO 13 I=1,N
80*      13  X(I)=10**X(I)
81*      GO TO 2
82*      14  IF(IFL.NE.'LOG10 ')*GO TO 16
83*      DO 15 I=1,N
84*      15  X(I)=ALOG10(X(I))
85*      GO TO 2
86*      16  IF(IFL.NE.'SQRT  ')*GO TO 18
87*      DO 17 I=1,N
88*      17  X(I)=SQRT(X(I))
89*      GO TO 2
90*      18  IF(IFL.NE.'EXP   ')*GO TO 20
91*      DO 19 I=1,N
92*      19  X(I)=EXP(X(I))
93*      GO TO 2
94*      20  IF(IFL.NE.'LAG   ')*GO TO 22
95*      WRITE(6,106)
96*      106  FORMAT(' NUMBER OF LAGS?')
97*      READ(5,200,END=53)J
98*      N=N-J
99*      DO 21 I=1,N
100*      21  X(I)=X(I+J)
101*      GO TO 2
102*      22  IF(IFL.NE.'TUKEY ')*GO TO 25
103*      WRITE(6,107)
104*      107  FORMAT(' LENGTH OF MOVING AVERAGE(ODD NUMBER)?')
105*      READ(5,200,END=53)J
106*      K=(J-1)/2
107*      WRITE(6,108)
108*      108  FORMAT(' HIGH PASS(HIGH) OR LOW PASS(LOW)?')
109*      READ(5,201,END=53)M
110*      DO 24 I=1,N
111*      24  IF(I.LE.K.OR.I.GT.N-K)GO TO 24
112*      A=0.
113*      DO 23 II=-K,K
114*      23  AL=-1./(K+1.)*(1.5+.5*COS(II*3.14159/(K+1.)))
115*      IF(II.EQ.0)AL=1.-1./(K+1.)
116*      A=A+AL*X(I+II)

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

117*      IF(M.EQ.'LOW')A=X(I)-A
118*      X(I-K)=A
119*      24      CONTINUE
120*      N=N-J+1
121*      GO TO 2
122*      25      IF(IFL.NE.'GOODMA')GO TO 30
123*      WRITE(6,107)
124*      READ(5,200,END=53) J
125*      K=(J-1)/2
126*      WRITE(6,115)
127*      115      FORMAT(' NUMBER OF TRIANGLES?')
128*      READ(5,200,END=53) NO
129*      WRITE(6,124)
130*      124      FORMAT(' DATA SPACING?')
131*      READ(5,200,END=53)DEL
132*      WRITE(6,116)
133*      116      FORMAT(' HIGH PASS(HIGH), LOW PASS(LOW), PASS BAND',
134*      ' (PASS) OR REJECT BAND(REJECT)?')
135*      READ(5,201,END=53)M
136*      IF(M.EQ.'HIGH'.OR.M.EQ.'LOW') GO TO 28
137*      WRITE(6,114)
138*      114      FORMAT(' CENTER FREQUENCY?')
139*      READ(5,200,END=53) W
140*      W=W*DEL*6.28318
141*      GO TO 29
142*      28      CP=.5*(K-1.-2.*NO)/K/DEL
143*      WRITE(6,117) CP
144*      117      FORMAT(' CUT-OFF FREQUENCY IS ',F10.7)
145*      WRITE(6,118)
146*      118      FORMAT(' DO YOU WANT TO CHANGE INPUT VALUES(YES/NO)?')
147*      READ(5,201,END=53)I
148*      IF(I.EQ.'YES') GO TO 25
149*      W=3.14159*(1.-FLOAT(NO)/FLOAT(K))
150*      29      DO 27 I=1,N
151*      IF(I.LE.K.OR.I.GT.N-K) GO TO 27
152*      A=0.
153*      DO 26 II=-K,K
154*      IF(II.EQ.ABS(K))AL=(-1)**(NO+1)*.08*NO/K*COS(K*W)
155*      IF(II.EQ.0) AL=2.*NO/K
156*      IF(II.NE.0.AND.II.NE.ABS(K))AL=2./K*(.54+.46*COS(
157*      1I*3.14159/K))*COS(II*W)*SIN(NO*II*3.14159/K)/SIN
158*      . (3.14159*II/K)
159*      26      A=A+AL*X(I+II)
160*      IF(M.EQ.'LOW'.OR.M.EQ.'REJECT')A=X(I)-A
161*      X(I-K)=A
162*      27      CONTINUE
163*      N=N-J+1
164*      GO TO 2
165*      30      IF(IFL.NE.'SCALE')GO TO 52
166*      WRITE(6,119)
167*      119      FORMAT(' SCALE OPERATOR(ADD/MPY)?')
168*      READ(5,201)ISO
169*      WRITE(6,120)
170*      120      FORMAT(' SCALE FACTOR?')
171*      READ(5,200)SF
172*      DO 31 I=1,N
173*      IF(ISO.EQ.'ADD')X(I)=X(I)+SF

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

174*      31      IF(ISO.EQ.'MPY')X(I)=X(I)*SF
175*      GO TO 2
176*      50      WRITE(6,109)
177*      109     FORMAT(' DO YOU WANT TO SEE PART OF THE SERIES',
178*      .        '(YES/NO)?')
179*      READ(5,201,END=53)IFL
180*      IF(IFL.NE.'YES')GO TO 33
181*      WRITE(6,123)
182*      123     FORMAT(' WHAT PART(INITIAL,FINAL,STEP)?')
183*      READ(5,200,END=53)I,J,K
184*      DO 32 L=I,J,K
185*      32      WRITE(6,200)X(L)
186*      33      WRITE(6,121)
187*      121     FORMAT(' DO YOU WANT THE FINAL SERIES STORED',
188*      .        '(YES/NO)?')
189*      READ(5,201,END=53)IFL
190*      IF(IFL.NE.'YES')GO TO 53
191*      WRITE(6,102)
192*      102     FORMAT(' OUTPUT DATA FORMAT?')
193*      READ(5,201,END=53)FMO
194*      CALL CSF(2,ASGH,I)
195*      WRITE(6,FMO)(X(I),I=1,N)
196*      WRITE(6,110)
197*      110     FORMAT(' SERIES STORED.')
198*      GO TO 53
199*      51      WRITE(6,111)L
200*      111     FORMAT(' LENGTH OF SERIES MUST BE LESS THAN',I5,', TRY AGA
201*      .IN.))
202*      GO TO 1
203*      52      WRITE(6,112)
204*      112     FORMAT(' FILTER NOT RECOGNIZED,TRY AGAIN.')
205*      WRITE(6,113)
206*      113     FORMAT(' FILTER?')
207*      GO TO 4
208*      53      WRITE(6,122)
209*      122     FORMAT(' FILTER TERMINATES.')
210*      CALL EXIT
211*      END

```

END OF COMPILATION:

NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE77

R.ACF,J,J

000 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:28:49.

N PROGRAM

PAGE USED: CODE(1) 000501; DATA(0) 004145; BLANK COMMON(2) 000000

ERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 CSF
 05 EX17
 06 NINTR\$
 07 NRDU\$
 10 NI01\$
 11 NI02\$
 12 NRLEW\$
 13 NRDU\$
 14 NRABU\$
 15 NRLEF\$
 16 NSTOP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

01	000040	1L	0001	000422	10L	0000	004004	100F	0000	004017	1
00	004033	103F	0000	004040	104F	0000	004043	105F	0000	004046	1
00	004055	108F	0000	004065	109F	0000	004073	110F	0000	004105	1
00	004121	122F	0001	000150	163G	0001	000200	174G	0001	000061	2
00	004023	201F	0001	000211	202G	0001	000226	207G	0001	000274	2
01	000340	251G	0001	000103	3L	0001	000416	301G	0001	000431	3
01	000452	51L	0001	000462	52L	0001	000470	53L	0000	003750	9
00 R	003726	AC	0000 R	003744	B	0000 R	000000	C	0000 R	003720	F
00 I	003745	IC	0000 I	003733	IC0	0000 I	003743	II	0000 I	003730	I
00 I	003731	L	0000 I	003735	M	0000 I	003742	MR	0000 I	003736	M
00 I	003737	NI	0003 L	000000	OPTION	0000 R	001750	Y			

1* C
 2* C TITLE ACF - AUTO-COVARIANCE/CORRELATION PROGRAM.
 3* C
 4* C AUTHOR R.R.SINGERS
 5* C
 6* C SPONSOR G.R.ANDERSEN
 7* C
 8* C DATE AUGUST, 1970
 9* C
 10* C KEY WORDS COVARIANCE
 11* C CORRELATION
 12* C
 13* C PURPOSE TO COMPUTE THE AUTO-COVARIANCES OF A DATA SERIES
 14* C AND IF DESIRED, THE AUTO-CORRELATIONS.
 15* C

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

16* C METHOD      THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
17* C            ASKING FOR CERTAIN PARAMETERS AND A DATA SERIES.
18* C            THE STANDARD METHOD OF COMPUTING THE AUTO-COVARIANCES
19* C            IS THEN APPLIED.
20* C
21* C NOTE        1) A DYNAMICALLY ASSIGNED FILE (UNIT 1) IS
22* C            USED TO SAVE THE AUTO-COVARIANCES (WHEN
23* C            SPECIFIED) FOR LATER USE.
24* C
25*              PARAMETER MX=1000
26*              DIMENSION C(MX),Y(MX),FMT(6),AC(2)/'QASG,T 1,F'/
27*              LOGICAL OPTION
28*              L=MX
29*              READ(5,200,END=53)FMT
30*              CALL CSF(2,AC,I)
31*              REWIND 1
32*              IF(OPTION('N'))GO TO 1
33*              WRITE(6,99)
34*              99  FORMAT(/' ACF COMPUTES THE AUTO-COVARIANCE/CORRELATION FU
35*              .NCTION OF A SERIES.'/' THE COVARIANCES ARE STORED ON UNIT 1 IN BINA
36*              .RY(IF DESIRED)'/' IN CONSECUTIVE ORDER.')
```

1

```

37*              WRITE(6,100)
38*              100  FORMAT(/' DO YOU WANT COVARIANCE(COV),CORRELATION(COR) OR
39*              . END?')
```

200

```

40*              READ(5,200,END=53)ICO
41*              FORMAT(6A6)
42*              IF(ICO.EQ.'END')GO TO 50
43*              <
44*              101  WRITE(6,101)
45*              FORMAT(' LENGTH OF SERIES?')
46*              READ(5,201,END=53)N
47*              201  FORMAT(' ')
48*              IF(N.GT.MX)GO TO 51
49*              3    WRITE(6,102)
50*              102  FORMAT(' NUMBER OF LAGS(ZERO INCLUDED)?')
```

102

```

51*              READ(5,201,END=53)M
52*              IF(M.GT.N)GO TO 52
53*              4    WRITE(6,103)
54*              103  FORMAT(' INPUT DATA FORMAT?')
```

103

```

55*              READ(5,200,END=53)FMT
56*              WRITE(6,104)
57*              104  FORMAT(' INPUT DATA:')
```

104

```

58*              READ(5,FMT,END=53)(Y(I),I=1,N)
59*              M1=M-1
60*              DO 6 I=0,M1
61*              N1=N-I
62*              A=0.
63*              DO 5 J=1,N1
64*              5    A=A+Y(J)*Y(J+I)
65*              C(I+1)=A/N
66*              6    IF(ICO.EQ.'COR'.AND.I.NE.0)C(I+1)=C(I+1)/C(1)
67*              A=C(1)
68*              IF(ICO.EQ.'COR') C(1)=1.
69*              MR=M/4
70*              IT=MR+1
71*              IF(MR.GT.10)MR=10
72*              DO 7 I=0,MR
73*              7    WRITE(6,105)(J,C(J+1),J=I,M1,II)
```


SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```
73*      105      FORMAT(4(I4,E15.8))
74*      IF(ICO.EQ.'COR')WRITE(6,106)A
75*      106      FORMAT(' VARIANCE=',E15.8)
76*      B=0.
77*      DO 8 I=1,N
78*      8        B=B+Y(I)
79*      B=B/N
80*      WRITE(6,107)B
81*      107      FORMAT(' MEAN=',E15.8)
82*      WRITE(6,108)
83*      108      FORMAT(' DO YOU WANT THE COVARIANCES STORED(YES/NO)?')
84*      READ(5,200,END=53)IC
85*      IF(IC.NE.'YES')GO TO 1
86*      WRITE(1)N,M
87*      IF(ICO.NE.'COR')GO TO 10
88*      DO 9 I=1,M
89*      9        C(I)=A*C(I)
90*      10       WRITE(1)(C(I),I=1,M)
91*      WRITE(6,109)
92*      109      FORMAT(' COVARIANCE STORED.')
93*      GO TO 1
94*      50       END FILE 1
95*      REWIND 1
96*      GO TO 53
97*      51       WRITE(6,110)L
98*      110      FORMAT(' SERIES LENGTH MUST BE LESS THAN',I10,' -TRY AGAIN',
99*      .N.')
```

```
100*      GO TO 2
101*      52      WRITE(6,111)
102*      111      FORMAT(' NUMBER OF LAGS CANNOT BE GREATER THAN LENGTH OF
103*      .SERIES-TRY AGAIN.')
```

```
104*      GO TO 3
105*      53      WRITE(6,122)
106*      122      FORMAT(' ACF TERMINATES.')
```

```
107*      CALL EXIT
108*      END
```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.PACF,J,J

000 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:29:01.

V PROGRAM

PAGE USED: CODE(1) 000555; DATA(0) 007457; BLANK COMMON(2) 000000

INTERNAL REFERENCES (BLOCK, NAME)

03 OPTION
04 EXIT
05 NINITS
06 NRDU\$
07 NIOIS
10 NIO2\$
11 NWDUS
12 NRBU\$
13 NSICP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

J1	000026 1L	0001	000413 10L	0000	007253 100F	0000	007317 1
J0	007350 104F	0000	007343 105F	0000	007376 106F	0000	007405 1
J0	007350 109F	0000	007363 110F	0001	000011 110G	0000	007420 1
J1	000110 147G	0001	000155 157G	0001	000213 172G	0000	007250 2
J1	000243 206G	0001	000273 224G	0001	000310 230G	0001	000350 2
J1	000455 277G	0001	000470 304G	0001	000525 323G	0001	000354 5
J1	000544 53L	0000 R	000000 A	0000 D	007224 A0	0000 D	007226 A
J0 D	007232 DEN	0000 R	007210 FMT	0000 I	007240 I	0000 I	007234 I
J0 I	007241 K	0000 I	007246 K0	0000 I	007242 L	0000 I	007243 L
J0 I	007247 MA	0000 I	007237 ML	0000 I	007245 M1	0000 I	007236 N
J3 L	000000 OPTION	0000 D	007216 R0	0000 D	007220 R1	0000 D	007222 R

1* C
2* C TITLE PACF - PARTIAL AUTO-CORRELATION PROGRAM.
3* C
4* C AUTHOR R.R.SINGERS
5* C
6* C SPONSOR G.R.ANDERSEN
7* C
8* C DATE AUGUST,1970
9* C
10* C KEY WORDS PARTIAL AUTO-CORRELATION
11* C
12* C PURPOSE TO COMPUTE THE PARTIAL AUTO-CORRELATION
13* C COEFFICIENTS AND THE CORRESPONDING VARIANCES
14* C OF UP TO 30 LAGS GIVEN THE AUTO-COVARIANCES.
15* C THE FIRST ORDER MOVING AVERAGE COEFFICIENT
16* C IS ALSO COMPUTED.
17* C
18* C METHOD THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

19* C ASKING FOR CERTAIN PARAMETERS. IT IS ASSUMED
20* C THAT ACF WAS EXECUTED AND THE AUTO-COVARIANCES
21* C SAVED. THE STANDARD METHOD OF COMPUTATION IS USED.
22* C
23* C NOTE 1) THE AUTO-COVARIANCES ARE ASSUMED TO
24* C BE STORED (ON UNIT 1) FROM ACF.
25* C
26* PARAMETER MX=60
27* DIMENSION A(MX,MX),CO(MX),V(MX),FMT(6)
28* DOUBLE PRECISION R0,R1,R2,A0,A1,NUM,DEN
29* LOGICAL OPTION
30* READ(5,200,END=53)FMT
31* 200 FORMAT(6A6)
32* IF(OPTION('N'))GO TO 1
33* WRITE(6,100)
34* 100 FORMAT(' PACF COMPUTES THE PARTIAL AUTO-CORRELATION AND A
35* ..R. COEFFICIENTS// UP TO ORDER K TOGETHER WITH THE RESIDUAL',
36* .' VARIANCES OF THE// FITTED A.R.'S UP TO ORDER K AND THE FIRST',
37* .' ORDER M.A. COEFFICIENTS.')
```

```

38* 1 WRITE(6,101)
39* 101 FORMAT(/' MAXIMUM ORDER OF K?')
40* READ(5,201,END=53)M
41* 201 FORMAT( )
42* IF(M.GT.MX)GO TO 51
43* READ(1)N,ML
44* READ(1)(CO(I),I=1,ML)
45* A(1,1)=CO(2)/CO(1)
46* DO 4 K=3,M
47* L=K-1
48* L1=L-1
49* R0=CO(1)
50* NUM=CO(K)/R0
51* DEN=1.00
52* DO 2 I=1,L1
53* A1=A(L1,I)
54* R1=CO(L-I+1)
55* R2=CO(I+1)
56* NUM=NUM-A1*R1/R0
57* 2 DEN=DEN-A1*R2/R0
58* A0=NUM/DEN
59* A(L,L)=A0
60* DO 3 J=1,L1
61* 3 A(L,J)=A(L1,J)-A(L,L)*A(L1,L-J)
62* 4 CONTINUE
63* M1=M-1
64* WRITE(6,103)
65* 103 FORMAT(/' PACF:')
66* WRITE(6,104)(A(J,J),J=1,M1)
67* 104 FORMAT(/(5E15.8))
68* WRITE(6,108)
69* 108 FORMAT(' DO YOU WANT RESIDUAL VARIANCES',
70* '(YES/NO)?')
71* READ(5,200,END=53)I
72* IF(I.NE.'YES')GO TO 5
73* DO 7 L=1,M1
74* V(L)=CO(1)
75* DO 6 J=1,L

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

76*      6      V(L)=V(L)-A(L,J)*CO(J+1)
77*      7      V(L)=(N-L)/(N-2.*L-1.)*V(L)
78*      WRITE(6,105)
79*      105     FORMAT(/' RESIDUAL VARIANCES:')
80*      WRITE(6,104)(V(I),I=1,M1)
81*      5      WRITE(6,109)
82*      109     FORMAT(' ORDER OF A.R. PROCESS TO BE VIEWED',
83*      .      '(0=NONE OR NO MORE)?')
84*      READ(5,201,END=53)K0
85*      IF(K0.EQ.0)GO TO 10
86*      WRITE(6,104)(A(K0,I),I=1,K0)
87*      GO TO 5
88*      10      WRITE(6,110)
89*      110     FORMAT(' DO YOU WANT THE FIRST ORDER M.A.',
90*      .      ' COEFFICIENTS(YES/NO)?')
91*      READ(5,200,END=53) MA
92*      IF(MA.NE.'YES') GO TO 53
93*      DO 9 K=1,M1
94*      DEN=1.D0
95*      NUM=A(M1,1)
96*      DO 8 I=1,K
97*      R1=A(M1,1)
98*      R2=A(M1,I+1)
99*      DEN=DEN+R1**2
100*      8      NUM=NUM+R1*R2
101*      DEN=DEN+(DBLE(A(M1,M1)))**2
102*      9      V(K)=NUM/DEN
103*      WRITE(6,106)
104*      106     FORMAT(/' FIRST ORDER M.A. COEFFICIENTS:')
105*      WRITE(6,104)(V(I),I=1,M1)
106*      GO TO 53
107*      51      L=MX
108*      WRITE(6,107)L
109*      107     FORMAT(' NUMBER OF LAGS CANNOT BE GREATER THAN',I3,' -TRY
110*      .AGAIN.')
```

```

111*      GO TO 1
112*      53      WRITE(6,111)
113*      111     FORMAT(' PACF TERMINATES.')
```

```

114*      CALL EXIT
115*      END
```

END OF COMPILATION:

NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.ASF,J,J

J00 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:29:30.

PROGRAM

PAGE USED: CODE(1) 001037; DATA(0) 004532; BLANK COMMON(2) 000000

JRNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 CSF
 05 EXIT
 06 NINTR\$
 07 NRDU\$
 08 NI01\$
 09 NI02\$
 10 NWDU\$
 11 NRBUS\$
 12 COS
 13 SIN
 14 SQRT
 15 NWBU\$
 16 NWEF\$
 17 NSTOP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

01	000151	1L	0000	004250	100F	0000	004317	102F	0000	004327	1
00	004377	105F	0000	004407	106F	0000	004413	107F	0000	004440	1
00	004454	110F	0000	004334	111F	0000	004463	112F	0000	004472	1
00	004353	115F	0000	004313	116F	0001	000011	121G	0001	000170	2
00	004326	201F	0001	000221	214G	0001	000322	240G	0001	000347	2
01	000500	302G	0001	000637	327G	0001	000754	371G	0001	001026	5
01	001023	7L	0001	000026	99L	0000	R 004214	ANU	0000	R 003722	A
00	R 000002	C	0000	R 003733	CHI	0000	R 004224	CL	0000	R 004231	C
00	R 004210	DEL	0000	R 004242	EF	0000	R 004235	EL1	0000	R 004213	E
00	R 001752	F	0000	R 004226	FM	0000	R 003725	FMT	0000	R 004241	F
00	I 004220	I	0000	I 004222	ICL	0000	I 004244	IF	0000	I 004205	I
00	I 004243	IU	0000	I 004211	IW	0000	I 003724	IS	0000	I 004227	K
00	I 004212	M	0000	I 004206	N	0000	I 004216	NM	0000	I 004207	N
00	I 004225	NU	0003	L 000000	OPTION	0000	R 000001	PI	0000	R 000000	P
00	R 004245	VR	0000	R 004232	VO	0000	R 004233	V1	0000	R 004237	V

1* C
 2* C TITLE ASF - AUTO-SPECTRUM PROGRAM.
 3* C
 4* C AUTHOR R.R.SINGERS
 5* C
 6* C SPONSOR G.R.ANDERSEN
 7* C
 8* C DATE AUGUST,1970

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

9*      C
10*     C KEY WORDS      AUTO-SPECTRUM
11*     C                SPECTRAL DENSITY
12*     C
13*     C PURPOSE        TO COMPUTE THE AUTO-SPECTRUM OF A DATA SERIES
14*     C                AND TO PLOT THE SPECTRUM WITH ITS CONFIDENCE
15*     C                LIMITS.
16*     C
17*     C METHOD          THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
18*     C                ASKING FOR CERTAIN PARAMETERS AND A DATA SERIES.
19*     C                IT IS ASSUMED THAT ACF WAS EXECUTED AND THE
20*     C                AUTO-COVARIANCES SAVED. THE STANDARD METHOD OF
21*     C                COMPUTATION IS USED.
22*     C
23*     C NOTES          1) THE COVARIANCES ARE ASSUMED TO BE
24*     C                STORE (ON UNIT 1) FROM ACF.
25*     C                2) A DYNAMICALLY ASSIGNED FILE ( UNIT 2)
26*     C                IS USED TO STORE THE AUTO-SPECTRUM
27*     C                (WHEN SPECIFIED).
28*     C
29*
30*     C                PARAMETER MX=1000
31*     C                DATA PIV,PI/.1591549,3.1415926/
32*     C                DIMENSION C(MX),F(MX),AS(2)/'QASG,T 2,F',/FMT(6)
33*     C                DIMENSION CH1(60,2)/
34*     C                . 0.004,0.103,0.352,0.711,1.145,1.635,2.167,2.733,3.325,3.940,4.575
35*     C                . 5.226,5.892,6.571,7.261,7.962,8.672,9.390,10.117,10.851,11.591,1
36*     C                . 2.338,13.091,13.848,14.611,15.379,16.151,16.928,17.708,18.493,19.
37*     C                . 281,20.072,20.867,21.664,22.465,23.269,24.075,24.884,25.695,26.50
38*     C                . 9,27.326,28.144,28.965,29.787,30.612,
39*     C                . 31.439,32.263,33.098,33.930,34.764,35.6,36.437,37.276,38.116,38.9
40*     C                . 58,39.801,40.646,41.492,42.339,43.188,
41*     C                . 3.841,5.991,7.815,9.488,11.0
42*     C                . 71,12.592,14.067,15.507,16.919,18.307,19.675,21.026,22.362,23.685
43*     C                . 24.996,26.296,27.587,28.869,30.144,31.410,32.671,33.924,35.172,3
44*     C                . 6.415,37.652,38.885,40.113,41.337,42.557,43.773,44.985,46.194,47.
45*     C                . 400,48.602,49.802,50.999,52.192,53.384,54.572,55.758,56.942,58.12
46*     C                . 4,59.304,60.481,61.656,
47*     C                . 62.83,64.001,65.171,66.339,67.505,68.669,69.832,70.993,72.153,73.
48*     C                . 311,74.463,75.624,76.778,77.931,79.082/
49*     C                DIMENSION IPT(50)/50*' '/
50*     C                DATA IL/'NO'/
51*     C                LOGICAL OPTION
52*     C                READ(5,201,END=53)FMT
53*     C                IF(OPTION('N'))GO TO 99
54*     C                WRITE(6,100)
55*     C                100  FORMAT(/' ASF COMPUTES THE AUTO SPECTRUM FUNCTION.'/
56*     C                .  ' IT IS ASSUMED THAT ACF WAS CALLED AND THE DESIRED'
57*     C                .  ' COVARIANCES STORED.'/ ' THE AUTO-SPECTRA ARE'
58*     C                .  ' STORED ON UNIT 2(IF DESIRED) CONSECUTIVELY.')

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

66*      201      FORMAT(6A6)
67*      WRITE(6,103)
68*      103      FORMAT(' BANDWIDTH PARAMETER?')
69*      READ(5,200,END=53)M
70*      IF(IW.EQ.'TUKEY')GO TO 1
71*      EM1=M-1
72*      ANU=2*N/EM1
73*      AU=1.
74*      WRITE(6,111)
75*      111      FORMAT(' NUMBER OF COVARIANCES TO BE USED?')
76*      READ(5,200,END=53) NM
77*      GO TO 2
78*      1      EM1=M-1.
79*      ANU=2.667*N/EM1
80*      AU=.75
81*      NM=M
82*      2      WRITE(6,104)
83*      104      FORMAT(' NUMBER OF FREQUENCY POINTS TO BE VIEWED?')
84*      READ(5,200,END=53)NQ
85*      IF(IL.NE.'YES')READ(1)(C(I),I=1,NN)
86*      ENQ1=NQ-1
87*      WRITE(6,115)
88*      115      FORMAT(' DO YOU WANT CONFIDENCE LIMITS(YES/NO)?')
89*      READ(5,201,END=53)ICL
90*      CU=1.
91*      CL=1.
92*      IF(ICL.NE.'YES')GO TO 25
93*      NU=FIX(ANU+.5)
94*      CU=ANU/CHI(NU,1)
95*      CL=ANU/CHI(NU,2)
96*      25      FM=0.
97*      DO 4 K=1,NQ
98*      TAU=K-1
99*      C0=COS(PI*TAU/ENQ1)
100*      V0=0.
101*      V1=0.
102*      DO 3 L=NM,2,-1
103*      EL1=L-1
104*      W=1.
105*      IF(IW.EQ.'DANIEL')W=SIN(EL1*PI/EM1)/(EL1*PI/EM1)
106*      IF(IW.EQ.'TUKEY')W=.5*(1.+COS(PI*EL1/EM1))
107*      V2=2.*C0*V1-V0+W*C(L)
108*      V0=V1
109*      V1=V2
110*      3      F(K)=DEL*(C(1)+2.*(V1*C0-V0))
111*      4      FM=AMAX0(FM,F(K))
112*      FX=FM*CU/49.
113*      WRITE(6,114)
114*      114      FORMAT(' DO YOU WANT FREQUENCY(FREQ.) OR'
115*      ' PERIOD(PERIOD) DISPLAYED?')
116*      READ(5,201,END=53)FP
117*      WRITE(6,105)FP
118*      105      FORMAT(' AUTO-SPECTRUM:'/2X,A6,' SPECTRUM')
119*      DO 5 I=1,NQ
120*      L=I-1
121*      IF(FP.NE.'PERIOD')EF=.5*L/ENQ1/DEL
122*      IF(FP.EQ.'PERIOD'.AND.L.EQ.0)EF=99.9999

```

```

123*      IF(FP.EQ.'PERIOD'.AND.L.NE.0)EF=2.*ENG1/L*DEL
124*      IU=IFIX(F(I)*CU/FX)+1
125*      IL=IFIX(F(I)*CL/FX)+1
126*      IF=IFIX(F(I)/FX)+1
127*      IF(IU.GT.50)IU=50
128*      IPT(IU)='+'
129*      IPT(IL)='*'
130*      IPT(IF)='.'
131*      WRITE(6,106)EF,F(I),IPT
132* 106      FORMAT(F8.4,E12.5,2X,50A1)
133*      IPT(IU)=' '
134*      IPT(IF)=' '
135* 5        IPT(IL)=' '
136*      VR=SQRT(AU*M/N)*100.
137*      IF(ICL.EQ.'YES')WRITE(6,107)NU,CU,CL,VR
138* 107      FORMAT(' THE 90% CONFIDENCE LIMITS FOR NU=',I2,' ARE: CU=
139*      , 'F10.5,' ,CL='F10.5/' THE SQRT OF VARIANCE RATIO IS:',F8.3,' %')
140*      WRITE(6,108)
141* 108      FORMAT(' DO YOU WANT THE SPECTRUM STORED(YES/NO)?')
142*      READ(5,201,END=53)IW
143*      IF(IW.NE.'YES')GO TO 6
144*      CALL CSF(2,AS,I)
145*      WRITE(2)M,DEL,NQ
146*      WRITE(2)(F(I),I=1,NQ)
147*      WRITE(6,109)
148* 109      FORMAT(' SPECTRUM STORED.')
149* 6        WRITE(6,110)
150* 110      FORMAT(' DO YOU HAVE ANOTHER SERIES(YES/NO)?')
151*      READ(5,201,END=53)IW
152*      IF(IW.NE.'YES')GO TO 7
153*      WRITE(6,112)
154* 112      FORMAT(' IS THE SERIES THE SAME(YES/NO)?')
155*      READ(5,201) IL
156*      GO TO 99
157* 7        END FILE 2
158* 53       WRITE(6,113)
159* 113      FORMAT(' ASF TERMINATES.')
160*      CALL EXIT
161*      END

```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.LSRA,J,J

000 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:29:18.

N PROGRAM

PAGE USED: CODE(1) 001076; DATA(0) 007410; BLANK COMMON(2) 000000

ERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 RESTEM
 05 EXIT
 06 CSF
 07 NINTR\$
 10 NRDU\$
 11 NIO1\$
 12 NIO2\$
 13 NWDU\$
 14 SQRT
 15 NSTOP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

01	000026	1L	0001	000617	10L	0000	007003	100F	0000	007042	1
00	007217	103F	0000	007053	105F	0000	007056	107F	0000	007064	1
00	007102	110F	0001	000011	110G	0000	007116	111F	0000	007124	1
00	007137	114F	0000	007145	115F	0000	007151	116F	0000	007156	1
01	000732	12L	0000	007265	120F	0000	007306	121F	0000	007335	1
00	007243	124F	0000	007255	125F	0000	007311	126F	0000	007324	1
00	007363	129F	0001	000140	160G	0001	000160	171G	0001	000173	1
00	007000	200F	0000	007041	201F	0001	000212	207G	0001	000232	2
01	000345	253G	0001	000366	260G	0001	000412	272G	0001	000455	3
01	000603	366G	0001	000705	423G	0001	000770	447G	0001	001015	4
01	000246	5L	0001	001041	51L	0001	001053	52L	0001	001065	5
01	000511	8L	0001	000520	9L	0000	007034	99F	0000	R 005675	A
00 R	006765	C	0000	R 006744	D	0000	R 006777	DEV	0000	R 006756	E
00 R	006767	FL	0000	R 006736	FMT	0000	I 006760	I	0000	I 006763	I
00 I	005733	IVAR	0000	I 006755	IW	0000	I 006752	IS	0000	I 006774	J
00 I	006762	L	0000	I 006772	M	0000	I 006761	N	0000	I 006753	N
00 I	006754	NV	0000	I 006766	NVAR	0003	L 000000	OPTION	0000	R 005752	R
00 R	005726	SIG	0000	R 006776	SSK	0000	R 006775	SSO	0000	R 006770	S
00 R	000000	X	0000	R 005670	XBAR						

1* C
 2* C TITLE LSRA - LEAST SQUARES MULTIPLE REGRESSION PROGRAM
 3* C WITH ANALYSIS OF VARIANCE PRINTOUT.
 4* C
 5* C AUTHOR R.R.SINGERS
 6* C
 7* C SPONSOR G.R.ANDERSEN
 8* C

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

9*   C DATE          AUGUST,1970
10*  C
11*  C KEY WORDS      REGRESSION
12*  C                LEAST SQUARES
13*  C
14*  C PURPOSE        TO COMPUTE THE LEAST SQUARES REGRESSION COEFFICIENTS
15*  C                AND THE ANALYSIS OF VARIANCE DATA OF TWO OR MORE
16*  C                DATA SERIES.
17*  C
18*  C METHOD          THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
19*  C                ASKING FOR CERTAIN PARAMETERS AND THE DATA SERIES.
20*  C                THE STANDARD FORWARD LEAST SQUARES REGRESSION
21*  C                TECHNIQUE IS USED.
22*  C
23*  C SUBPROGRAMS     RESTEM - UNIVAC 1108 STAT-PACK FORWARD
24*  C USED            REGRESSION SUBROUTINE.
25*  C
26*  C NOTE            1) A DYNAMICALLY ASSIGNED FILE (UNIT 8) IS
27*  C                USED TO SAVE THE RESIDUALS (WHEN SPECIFIED).
28*  C
29*  C                PARAMETER MXL=500,MXV=5
30*  C                DIMENSION X(MXL,MXV),W(MXL),XBAR(MXV),A(MXV,MXV),SIG(MXV)
31*  C                ,IVAR(MXV),B(MXV),SB(MXV),R(MXL),FMT(6)
32*  C                DIMENSION D(6)
33*  C                LOGICAL OPTION
34*  C                READ(5,200,END=53)FMT
35*  C                200  FORMAT(6A6)
36*  C                IF(OPTION('N'))GO TO 1
37*  C                WRITE(6,100)
38*  C                100  FORMAT(/' LSRA IS A STEPWISE MULTIPLE REGRESSION PROGRAM'
39*  C                ,/' WITH ANALYSIS OF VARIANCE PRINTOUT.'
40*  C                ,/' THE RESIDUALS ARE STORED ON UNIT 8(IF DESIRED).'/)
41*  C                1    WRITE(6,99)
42*  C                99   FORMAT(' NUMBER OF OBSERVATIONS?')
43*  C                READ(5,201,END=53)NL
44*  C                201  FORMAT( )
45*  C                IF(NL.GT.MXL)GO TO 51
46*  C                WRITE(6,101)
47*  C                101  FORMAT(' NUMBER OF VARIABLES(DEPENDENT AND INDEPENDENT)?'
48*  C                ,')
49*  C                2    READ(5,201,END=53)NV
50*  C                IF(NV.GT.MXV)GO TO 52
51*  C                IW=0
52*  C                3    WRITE(6,105)
53*  C                105  FORMAT(' F LEVEL?')
54*  C                READ(5,201,END=53)EFIN
55*  C                EFOUT=EFIN
56*  C                WRITE(6,107)
57*  C                107  FORMAT(' DEPENDENT VARIABLE FORMAT?')
58*  C                READ(5,200,END=53)FMT
59*  C                WRITE(6,108)
60*  C                108  FORMAT(' DEPENDENT VARIABLE DATA:')
61*  C                READ(5,FMT)(X(I,NV),I=1,NL)
62*  C                N=NV-1
63*  C                DO 4 L=1,N
64*  C                WRITE(6,109)L
65*  C                109  FORMAT(' INDEPENDENT VARIABLE',I2,' FORMAT?')

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SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

66*      READ(5,200,END=53)FMT
67*      WRITE(6,110)L
68*      110      FORMAT(' INDEPENDENT VARIABLE',I2,' DATA:')
69*      4        READ(5,FMT)(X(I,L),I=1,NL)
70*      IND=0
71*      ISTEP=-1
72*      5        CALL RESTEM(X,NL,NV,MXL,MXV,W,IW,EFIN,EFOUT,XBAR,A,SIG,C,
73*      .         NVAR,FL,SY,NOIN,IVAR,B,SB,R,IND)
74*      IF(IND.EQ.0)GO TO 10
75*      ISTEP=ISTEP+1
76*      IF(ISTEP.NE.0)GO TO 7
77*      WRITE(6,102)(I,XBAR(I),I=1,N)
78*      102      FORMAT('/ MEANS:/(3(I5,E15.8)))
79*      WRITE(6,111)
80*      111      FORMAT('/ CORRELATION COEFFICIENTS:')
81*      M=N-1
82*      DO 6 I=1,M
83*      K=I+1
84*      6        WRITE(6,112)(I,J,A(I,J),J=K,N)
85*      112      FORMAT(3(4X,I2,' VS',I2,' = ',F10.6))
86*      WRITE(6,113)(I,A(I,NV),I=1,N)
87*      113      FORMAT(3(4X,I2,' VS Y = ',F10.6))
88*      WRITE(6,114)SY
89*      114      FORMAT(' STANDARD ERROR OF Y =',F12.6)
90*      D(4)=SY**2
91*      D(3)=NL-1.
92*      D(2)=D(4)*D(3)
93*      D(1)=1.E30
94*      SS0=D(2)
95*      WRITE(6,103)D
96*      GO TO 5
97*      7        WRITE(6,115)ISTEP
98*      115      FORMAT('/ STEP NO.',I3)
99*      IF(NVAR.GE.0)GO TO 8
100*      NVAR=-NVAR
101*      FL=-FL
102*      WRITE(6,116)NVAR
103*      116      FORMAT(5X,' VARIABLE REMOVED:',I3)
104*      GO TO 9
105*      8        WRITE(6,117)NVAR
106*      117      FORMAT(5X,' VARIABLE ENTERING:',I3)
107*      9        WRITE(6,118)FL,SY,C,(IVAR(I),B(I),SB(I),I=1,NOIN)
108*      118      FORMAT(5X,' FLEVEL',F13.6/6X,' STANDARD ERROR OF Y',F13.6/
109*      .         6X,' CONSTANT',E13.6/13X,' VARIABLE COEFFICIENT STD.
110*      .ERROR OF COEFF'/(17X,' X',I2,E16.8,E18.8))
111*      D(4)=SY**2
112*      D(3)=D(3)-1.
113*      SSK=D(4)*D(3)
114*      D(1)=D(2)-SSK
115*      D(2)=SSK
116*      D(5)=SQRT(D(1)/D(4))
117*      D(6)=1.-D(2)/SS0
118*      WRITE(6,103)D
119*      103      FORMAT('/ SSVAR=',F13.6,2X,' SSRES=',F13.6,2X
120*      .         , 'DFRES=',F13.6/ ' MSRES=',F13.6,6X,' T=',
121*      .         F13.6/ ' MULTCOR=',F12.6/)
122*      IF(ISTEP.LT.NV)GO TO 5

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SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

123*          IND=-1
124*          GO TO 5
125*      10      WRITE(6,124)
126*      124      FORMAT(' DO YOU WANT TO SEE SOME OF THE ',
127*          .      'DEVIATIONS(YES/NO)?')
128*          READ(5,200,END=53) I
129*          IF(I.NE.'YES') GO TO 12
130*          WRITE(6,125)
131*      125      FORMAT(' WHAT PART(INITIAL,FINAL,STEP)?')
132*          READ(5,201,END=53) J,K,L
133*          WRITE(6,120)
134*      120      FORMAT('/' PREDICTED VS. ACTUAL RESULTS: '/' OB. NO.',4X,
135*          .      'ACTUAL',4X,'PREDICTED',4X,'%DEVIATION')
136*          DO 11 I=J,K,L
137*          DEV=(X(I,NV)-R(I))/X(I,NV)*100.
138*      11      WRITE(6,121) I,X(I,NV),R(I),DEV
139*      121      FORMAT(I5,2E13.6,F10.2)
140*          WRITE(6,126)
141*      126      FORMAT(' DO YOU WANT THE RESIDUALS STORED(YES/NO)?')
142*          READ(5,200,END=53) I
143*          IF(I.NE.'YES') CALL EXIT
144*          DO 13 I=1,NL
145*      13      R(I)=X(I,NV)-R(I)
146*          CALL CSF(2,'WASG,T 8,F',I)
147*          WRITE(6,127)
148*      127      FORMAT(' OUTPUT DATA FORMAT?')
149*          READ(5,200,END=53) FMT
150*          WRITE(8,FMT) (R(I),I=1,NL)
151*          WRITE(6,128)
152*      128      FORMAT(' SERIES STORED.')
153*          GO TO 53
154*      51      I=MXL
155*          WRITE(6,122) I
156*      122      FORMAT(' NUMBER OF OBSERVATIONS MUST BE LESS THAN',I5,' T
157*          .RY AGAIN')
158*          GO TO 1
159*      52      I=MXV
160*          WRITE(6,123) I
161*      123      FORMAT(' NUMBER OF VARIABLES MUST BE LESS THAN',I5,' TRY
162*          .AGAIN')
163*          GO TO 2
164*      53      WRITE(6,129)
165*      129      FORMAT(' LSR TERMINATES.')
166*          CALL EXIT
167*          END

```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE77

R.XCF,J,J

000 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:29:45.

N PROGRAM

RAGE USED: CODE(1) 000502; DATA(0) 010063; BLANK COMMON(2) 000000

ERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 EXIT
 05 NINTR\$
 06 NRDUS
 07 NIO1\$
 10 NIO2\$
 11 NWDUS
 12 NREW\$
 13 NRBUS
 14 SQRT
 15 NWBUS
 16 NWEF\$
 17 NSTOP\$

RAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

00	007667	100F	0000	007746	101F	0000	007761	103F	0000	007771	1
00	010011	106F	0000	010014	107F	0001	000011	107G	0000	010025	1
01	000061	133G	0001	000104	143G	0001	000144	161G	0001	000156	1
01	000213	200G	0000	007760	201F	0001	000232	204G	0001	000241	2
01	000332	240G	0001	000356	244G	0001	000421	267G	0001	000422	2
01	000446	303G	0001	000471	53L	0001	000432	8L	0001	000026	9
00	R 007650	B	0000	R 000000	C	0000	R 007640	FMT	0000	I 007654	1
00	I 007647	IC0	0000	I 007662	II	0000	I 007646	IS	0000	I 007651	J
00	I 007653	M	0000	I 007661	MR	0000	I 007655	M1	0000	I 007652	N
03	L 000000	OPTION	0000	R 003720	Y						

1* C
 2* C TITLE XCF - CROSS-COVARIANCE/CORRELATION PROGRAM.
 3* C
 4* C AUTHOR R.R.SINGERS
 5* C
 6* C SPONSOR G.R.ANDERSEN
 7* C
 8* C DATE AUGUST, 1970
 9* C
 10* C KEY WORDS CROSS-COVARIANCE
 11* C CROSS-CORRELATION
 12* C
 13* C PURPOSE TO COMPUTE THE CROSS-COVARIANCES OF TWO DATA SERIES
 14* C AND IF DESIRED, THE CROSS-CORRELATIONS OF TWO DATA
 15* C SERIES.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

16*  C
17*  C METHOD      THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
18*  C              ASKING FOR CERTAIN PARAMETERS AND TWO DATA SERIES.
19*  C              IT IS ASSUMED THAT ACF WAS EXECUTED AND THE AUTO-
20*  C              COVARIANCES SAVED. THE STANDARD METHOD OF COMPUTATION
21*  C              IS USED.
22*  C
23*  C NOTES      1) IT IS ASSUMED THAT THE AUTO-COVARIANCES
24*  C              ARE STORED (ON UNIT 1) FROM ACF.
25*  C              2) THE CROSS-COVARIANCES ARE STORED AFTER
26*  C              THE AUTO-COVARIANCES (ON UNIT 1).
27*  C
28*              PARAMETER MX=1000
29*              DIMENSION C(MX,2),Y(MX,2),FMT(6)
30*              LOGICAL OPTION
31*              READ(5,200,END=53)FMT
32*  200          FORMAT(6A6)
33*              IF(OPTION('N'))GO TO 99
34*              WRITE(6,100)
35*  100          FORMAT(/' XCF COMPUTES THE CROSS-COVARIANCE/-CORRELATION',
36*  .            ' FUNCTION OF TWO SERIES.'/' IT IS ASSUMED THAT THE ',
37*  .            ' AUTO-COVARIANCES OF THE TWO SERIES ARE'/' STORED ON ',
38*  .            ' UNIT 1. THE CROSS-COVARIANCES ARE STORED ON '/' UNIT',
39*  .            ' 1(IF DESIRED) AFTER THE AUTO-COVARIANCES.')
```

```

40*  99          REWIND 1
41*              WRITE(6,101)
42*  101          FORMAT(' DO YOU WANT COVARIANCE(COV) OR CORRELATION(COR)?')
43*              READ(5,200,END=53)ICO
44*  201          FORMAT( )
45*              B=1.
46*              DO 3 J=1,2
47*              WRITE(6,103)J
48*  103          FORMAT(' INPUT DATA FORMAT OF SERIES',I2,'?')
49*              READ(5,200,END=53)FMT
50*              WRITE(6,104)J
51*  104          FORMAT(' INPUT DATA OF SERIES',I2,':')
52*              READ(1)N,M
53*              READ(5,FMT,END=53)(Y(I,J),I=1,N)
54*              READ(1)(C(I,J),I=1,M)
55*  3            B=B*C(1,J)
56*              B=SQRT(B)
57*              M1=M-1
58*              DO 5 I=0,M1
59*              NI=N-I
60*              DO 5 J=1,2
61*              A=0.
62*              DO 4 K=1,NI
63*  4            A=A+Y(K,J)*Y(K+I,3-J)
64*              C(I+1,J)=A/N
65*  5            IF(ICO.EQ.'COR')C(I+1,J)=C(I+1,J)/B
66*              MR=M/4
67*              II=MR+1
68*              IF(MR.GT.10)MR=10
69*              DO 6 K=1,2
70*              I=3-K
71*              WRITE(6,105)ICO,K,I
72*  105          FORMAT(/' CROSS-',A3,'. FOR SERIES',I3,' VS.',I3,'.')
```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```
73*      DO 6 I=0,MR
74*      6      WRITE(6,106)(J,C(J+1,K),J=I,M1,II)
75*      106     FORMAT(4(I4,E15.8))
76*      WRITE(6,107)
77*      107     FORMAT(' DO YOU WANT THE COVARIANCES STORED(YES/NO)?')
78*      READ(5,200,END=53)IC
79*      IF(IC.NE.'YES')GO TO 53
80*      IF(IC.NE.'COR')GO TO 8
81*      DO 7 J=1,2
82*      DO 7 I=1,M
83*      7      C(I,J)=B*C(I,J)
84*      8      WRITE(1)((C(I,J),I=1,M),J=1,2)
85*      WRITE(6,108)
86*      108     FORMAT(' COVARIANCES STORED. ')
87*      END FILE 1
88*      REWIND 1
89*      53      WRITE(6,111)
90*      111     FORMAT(' XCF TERMINATES. ')
91*      CALL EXIT
92*      END
```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.XSF,J,J

J00 COMPILED BY 1201 BC57E ON 01 DEC 70 AT 12:30:29.

PROGRAM

PAGE USED: CODE(1) 001174; DATA(0) 014152; BLANK COMMON(2) 000000

INTERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 ATANH
 05 EXIT
 06 NINTX\$
 07 NRDU\$
 10 NIO1\$
 11 NIO2\$
 12 NWDU\$
 13 NRBUS\$
 14 SQRT
 15 COS
 16 SIN
 17 ATAN2
 20 NWBUS\$
 21 NSTOP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

J0	013713	100F	0000	013774	105F	0000	014010	106F	0000	014024	1
J0	014060	109F	0000	014101	110F	0000	014030	111F	0000	014045	1
J1	000011	113G	0001	000050	134G	0001	000077	146G	0001	000110	1
J1	000210	175G	0000	013710	200F	0000	013773	201F	0001	000223	2
J1	000413	244G	0001	000436	257G	0001	000445	254G	0001	000452	2
J1	000657	334G	0001	000723	351G	0001	000750	367G	0001	001100	4
J1	001146	442G	0001	001163	53L	0001	000026	99L	0000	R 013660	A
J4 R	000000	ATANH	0000	R 000000	C	0000	R 013664	CO	0000	R 013702	D
J0 R	013703	EF	0000	R 013673	EL1	0000	R 013656	EM1	0000	R 013657	E
J0 R	003720	F	0000	R 013560	FMT	0000	R 013701	FP	0000	I 013651	I
J0 I	013706	IP	0000	I 013562	IPT	0000	I 013644	IS	0000	I 013652	J
00 I	013672	L	0000	I 013653	M	0000	I 013647	N	0000	I 013650	N
00 R	013676	OD	0003	L 000000	OPTION	0000	R 013705	PH	0000	R 013646	P
00 R	007640	Q	0000	R 013665	SI	0000	R 013663	TAU	0000	R 013707	T
00 R	013667	V1	0000	R 013677	V2	0000	R 013674	W	0000	R 013670	2
00 R	013700	Z2									

1* C
 2* C TITLE XSF - CROSS-SPECTRUM FUNCTION.
 3* C
 4* C AUTHOR R.R.SINGERS
 5* C
 6* C SPONSOR G.R.ANDERSEN
 7* C

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

8*   C DATE          SEPTEMBER,1970
9*   C
10*  C KEY WORDS     CO-SPECTRUM
11*  C               QUADRATURE
12*  C
13*  C PURPOSE       TO COMPUTE THE CO-SPECTRUM,QUADRATURE,PHASE,AND
14*  C               COHERENCE BETWEEN TWO DATA SERIES.
15*  C
16*  C METHOD         THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
17*  C               ASKING FOR CERTAIN PARAMETERS AND TWO DATA SERIES.
18*  C               IT IS ASSUMED THAT ACF,XCF,AND ASF HAVE BEEN
19*  C               EXECUTED AND THE AUTO-COVARIANCES,CROSS-COVARIANCES,
20*  C               AND THE AUTO-SPECTRA(USING THE TUKEY WINDOW)
21*  C               HAVE BEEN SAVED. THE STANDARD METHOD OF COMPUTATION
22*  C               IS USED.
23*  C
24*  C NOTES          1) THE AUTO AND CROSS COVARIANCES ARE ASSUMED TO BE
25*  C               STORED(ON UNIT 1) FROM ACF AND XCF.
26*  C               2) THE AUTO SPECTRA ARE ASSUMED TO BE STORED(ON
27*  C               UNIT 2) FROM ASF.
28*  C
29*                   PARAMETER MX=1000
30*                   DIMENSION C(MX,2),F(MX,2),Q(MX,2),FMT(2),IPT(50)/50*
31*                   ' '/
32*                   DATA PIV,PI/.1591549,3.1415926/
33*                   LOGICAL OPTION
34*                   READ(5,200,END=53)FMT
35*                   200   FORMAT(2A6)
36*                   IF(OPTION('N'))GO TO 99
37*                   WRITE(6,100)
38*                   100   FORMAT(/' XSF COMPUTES THE CROSS-SPECTRA FUNCTIONS FOR',
39*                   ./' THE TUKEY WINDOW.'/' IT IS ASSUMED THAT THE AUTO- AND C
40*                   .ROSS-COVARIANCES ARE STORED ON/' UNIT 1 AND THAT THE AUTO-SPECTRA
41*                   .ARE STORED ON UNIT 2.'/' THE CROSS SPECTRA ARE STORED ON UNIT 2 AF
42*                   .TER THE AUTO-SPECTRA(IF DESIRED).')
43*                   201   FORMAT( )
44*                   99    READ(1)N,NN
45*                   READ(1)((C(I,1),I=1,NN)
46*                   READ(1)N,NN
47*                   READ(1)((C(I,1),I=1,NN)
48*                   READ(1)((C(I,J),I=1,NN),J=1,2)
49*                   READ(2)M,DEL,NQ
50*                   EM1=M-1
51*                   ENQ1=NQ-1.
52*                   AMU=2.667*N/EM1
53*                   ANU=1.65/SQRT(AMU)
54*                   DO 2 I=1,2
55*                   J=MOD(I,2)+1
56*                   DO 2 K=1,NQ
57*                   TAU=K-1
58*                   CO=COS(PI*TAU/ENQ1)
59*                   SI=SIN(PI*TAU/ENQ1)
60*                   V0=0.
61*                   V1=0.
62*                   Z0=0.
63*                   Z1=0.
64*                   DO 1 L=M,2,-1

```


SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

65*      EL1=L-1
66*      W=.5*(1.+COS(PI*EL1/EM1))
67*      EV=.5*(C(L,I)+C(L,J))
68*      OD=.5*(C(L,I)-C(L,J))
69*      V2=2.*C0*V1-V0+W*EV
70*      Z2=2.*C0*Z1-Z0+W*OD
71*      V0=V1
72*      V1=V2
73*      Z0=Z1
74*      1      Z1=Z2
75*      F(K,I)=DEL*(C(1,I)+2.*(V1*C0-V0))
76*      2      Q(K,I)=2.*PIV*Z1*SI
77*      WRITE(6,105)
78*      105      FORMAT(' DO YOU WANT FREQUENCY(FREQ.) OR PERIOD(PERIOD)',
79*      .      /' DISPLAYED?')
80*      READ(5,200,END=53)FP
81*      READ(2)(C(I,1),I=1,NQ)
82*      READ(2)I,D,J
83*      READ(2)(C(I,2),I=1,NQ)
84*      DO 3 I=1,NQ
85*      D=C(I,1)*C(I,2)
86*      DO 3 J=1,2
87*      C(I,J)=ATANH(SQRT((F(I,J)**2+Q(I,J)**2)/D))
88*      3      FMT(J)=MAX(ABS(C(I,J)),FMT(J))
89*      FMT(1)=FMT(1)/49.
90*      FMT(2)=FMT(2)/49.
91*      I=1
92*      J=2
93*      WRITE(6,106)FP,I,J
94*      106      FORMAT(/2X,A6,' ARCTANH(COHERENCE) FOR SERIES',I2,' VS.',
95*      .      ,I2,' .')
96*      DO 4 K=1,NQ
97*      L=K-1
98*      IF(FP.NE.'PERIOD')EF=.5*L/ENQ1/DEL
99*      IF(FP.EQ.'PERIOD'.AND.L.NE.0)EF=2.*ENQ1/L*DEL
00*      IF(FP.EQ.'PERIOD'.AND.L.EQ.0)EF=99.9999
01*      IF=IFIX(C(K,I)/FMT(I))+1
02*      IF(IF.GT.50)IF=50
03*      IF(IF.LT.1)IF=1
04*      IPT(IF)='+'
05*      WRITE(6,107)EF,C(K,I),IPT
06*      107      FORMAT(F8.4,E12.5,2X,50A1)
07*      4      IPT(IF)=' '
08*      IF=IFIX(ANU/FMT(I))+1
09*      IPT(1)='*'
10*      IPT(IF)='*'
11*      WRITE(6,111)AMU,IPT
12*      111      FORMAT(' NU='F5.0,13X,50A1)
13*      IPT(1)=' '
14*      IPT(IF)=' '
15*      WRITE(6,108)FP,I,J
16*      108      FORMAT(/3X,A6,' PHASE FOR SERIES',I2,' VS.',I2,' .')
17*      DO 5 K=1,NQ
18*      PH=57.2958*ATAN2(Q(K,I),F(K,I))
19*      L=K-1
20*      IF(FP.NE.'PERIOD')EF=.5*L/ENQ1/DEL
21*      IF(FP.EQ.'PERIOD'.AND.L.EQ.0)EF=99.9999

```

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```
122*      IF(IP.EQ.'PERIOD'.AND.L.NE.0)EF=2.*ENQ1/L*DEL
123*      IP=IFIX(PH/7.16)+25
124*      IF(IP.GT.50)IP=50
125*      IF(IP.LT.1)IP=1
126*      IPT(25)='*'
127*      IPT(IP)='+'
128*      WRITE(6,107)EF,PH,IPT
129*      IPT(25)=' '
130*      5      IPT(IP)=' '
131*      WRITE(6,112)
132*      112      FORMAT(T21,'*',25X,'*',25X,'*'/T19,'-180',
133*      .      24X,'0',24X,'180')
134*      WRITE(6,109)
135*      109      FORMAT(/' DO YOU WANT THE CO-SPECTRA AND QUADRATURES',/
136*      .      ' STORED FOR TIME SERIES REGRESSION(YES/NO)?')
137*      READ(5,200,END=53)IS
138*      IF(IS.NE.'YES')GO TO 53
139*      WRITE(2)((F(I,J),I=1,NQ),J=1,2)
140*      WRITE(6,110)
141*      110      FORMAT(' SERIES STORED.')
142*      53      WRITE(6,113)
143*      113      EFORMAT(' XSF TERMINATES.')
144*      CALL EXIT
145*      END
```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.COMB,J,J

J00 COMPILED BY 1201 BCS7E ON 01 DEC 70 AT 12:31:15.

PROGRAM

PAGE USED: CODE(1) 000522; DATA(0) 004161; BLANK COMMENT(2) 000000

INTERNAL REFERENCES (BLOCK, NAME)

J3 OPTION
 J4 CSF
 J5 EXIT
 J6 NINTR\$
 J7 NRDU\$
 L0 NI01\$
 L1 NI02\$
 L2 NWDU\$
 J3 NSTOP\$

PAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

J1	000026 1L	0001	000240 10L	0000	003743 100F	0000	003776 I
J0	004015 103F	0000	004022 104F	0000	004030 105F	0000	004035 I
J0	004055 108F	0000	004066 109F	0000	004073 110F		000011 I
J0	004110 112F	0000	004122 113F	0000	004136 114F		000255 I
J1	000301 14L	0001	000102 145G	0001	000364 15L		000124 I
J0	004006 201F	0001	000201 205G	0001	000216 215G	0001	000233 2
J1	000272 247G	0001	000360 276G	0001	000132 3L	0001	000424 3
J1	000154 4L	0001	000455 50L	0001	000465 51L	0001	000477 5
J1	000206 6L	0001	000213 8L	0000 R	003726 AS68	0000 R	003720 F
J0 I	003735 10P	0000 I	003730 1\$	0000 I	003736 J	0000 I	003733 K
J0 I	003732 M	0000 I	003734 N	0003 L	000000 OPTION	0000 R	000000 X

1*	C	
2*	C TITLE	COMB - A PROGRAM TO COMBINE TWO DATA SERIES.
3*	C	
4*	C AUTHOR	R.R.SINGERS
5*	C	
6*	C SPONSOR	G.R.ANDERSEN
7*	C	
8*	C DATE	NOVEMBER, 1970
9*	C	
10*	C KEY WORDS	COMBINE,
11*	C	CONCATINATE
12*	C	
13*	C PURPOSE	TO COMBINE TWO DATA SERIES USING ONE OF FIVE
14*	C	OPERATORS;ADD,SUB,MPY,DIV,CON.
15*	C	
16*	C METHOD	THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
17*	C	ASKING FOR CERTAIN PARAMETERS AND APPLYING THEM TO
18*	C	TWO INPUT DATA SERIES. THE RESULTANT SERIES MAY THEN

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

19*   C           BE STORED.
20*   C
21*   C NOTE      1) A DYNAMICALLY ASSIGNED FILE (UNIT 8) IS USED TO
22*   C           STORE THE FINAL SERIES.
23*   C
24*           PARAMETER MX=1000
25*           DIMENSION X(MX,2),FMT(6),
26*           ASGB(2)/'QASG,T 8,F'/
27*           LOGICAL OPTION
28*           READ(5,200,END=53)FMT
29*   200          FORMAT(6A6)
30*           IF(OPTION('N'))GO TO 1
31*           WRITE(6,100)
32*   100          FORMAT(' COMB COMBINES TWO SERIES BY ONE OF THE FOLLOWING
33*           . SERIES: '/' ADD,SUB,MPY,DIV,CON(CONCATINATE) '/' THE RESULTANT SERI
34*           . ES IS STORED ON UNIT 8(IF DESIRED).')
35*   1           DO 2 I=1,2
36*           WRITE(6,101)I
37*   101          FORMAT(' LENGTH OF SERIES',I2,' TO BE READ IN?')
38*           READ(5,201,END=53)M
39*   201          FORMAT( )
40*           IF(M.GT.MX)GO TO 51
41*           WRITE(6,102)I
42*   102          FORMAT(' INPUT DATA',I2,' FORMAT?')
43*           READ(5,200,END=53)FMT
44*           WRITE(6,103)I
45*   103          FORMAT(' INPUT DATA',I2,' :')
46*   2           READ(5,FMT)(X(K,I),K=1,M)
47*   3           WRITE(6,104)
48*   104          FORMAT(' LENGTH OF OUTPUT SERIES?')
49*           READ(5,201,END=53)N
50*           IF(N.GT.2*MX)GO TO 52
51*   4           WRITE(6,105)
52*   105          FORMAT(' OPERATOR TO BE USED?')
53*           READ(5,200,END=53)IOP
54*           IF(IOP.NE.'ADD')GO TO 6
55*           DO 5 J=1,N
56*           X(J,1)=X(J,1)+X(J,2)
57*           GO TO 14
58*   6           IF(IOP.NE.'SUB')GO TO 8
59*           DO 7 J=1,N
60*   7           X(J,1)=X(J,1)-X(J,2)
61*           GO TO 14
62*   8           IF(IOP.NE.'MPY')GO TO 10
63*           DO 9 J=1,N
64*   9           X(J,1)=X(J,1)*X(J,2)
65*           GO TO 14
66*   10          IF(IOP.NE.'DIV')GO TO 12
67*           DO 11 J=1,N
68*   11          X(J,1)=X(J,1)/X(J,2)
69*           GO TO 14
70*   12          IF(IOP.NE.'CON')GO TO 50
71*           K=N-M+1
72*           L=0
73*           DO 13 J=K,N
74*           L=L+1
75*   13          X(J,1)=X(L,2)

```


SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

76*      14      WRITE(6,106)
77*      106     FORMAT(' DO YOU WANT TO SEE PART OF THE SERIES(YES/NO)?')
78*      READ(5,200,END=53)IOP
79*      IF(IOP.NE.'YES')GO TO 15
80*      WRITE(6,107)
81*      107     FORMAT(' WHAT PART (INITIAL,FINAL,STEP)?')
82*      READ(5,201,END=51)I,J,K
83*      WRITE(6,201)(X(L,1),L=I,J,K)
84*      15      WRITE(6,108)
85*      108     FORMAT(' DO YOU WANT THE RESULTANT SERIES STORED(YES/NO)'
86*      .        )
87*      READ(5,200,END=53)IOP
88*      IF(IOP.NE.'YES')GO TO 53
89*      WRITE(6,109)
90*      109     FORMAT(' OUTPUT DATA FORMAT?')
91*      READ(5,200,END=53)FMT
92*      CALL CSF(2,ASG8,I)
93*      WRITE(8,FMT)(X(I,1),I=1,N)
94*      WRITE(6,110)
95*      110     FORMAT(' SERIES STORED.')
96*      GO TO 53
97*      50      WRITE(6,111)IOP
98*      111     FORMAT(1X,A6,' IS NOT A RECOGNIZED OPERATOR,TRY AGAIN.')
99*      GO TO 4
100*     51      L=MX
101*     WRITE(6,112)L
102*     112     FORMAT(' LENGTH OF SERIES MUST BE LESS THAN',I2,
103*     .        ' TRY AGAIN.')
104*     GO TO 1
105*     52      L=2*MX
106*     WRITE(6,113)L
107*     113     FORMAT(' LENGTH OF OUTPUT SERIES MUST BE LESS THAN',I5,
108*     .        ' TRY AGAIN.')
109*     GO TO 3
110*     53      WRITE(6,114)
111*     114     FORMAT(' COMB TERMINATES.')
112*     CALL EXIT
113*     END

```

END OF COMPILATION: NO DIAGNOSTICS.

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

R.LSRP,J,J

000 COMPILED BY 1201 BCS7E ON 03 DEC 70 AT 08:37:28.

N PROGRAM

RAGE USED: CODE(1) 001012; DATA(0) 007326; BLANK COMMON(2) 000000

ERNAL REFERENCES (BLOCK, NAME)

03 OPTION
 04 REBSOM
 05 CSF
 06 EXIT
 07 NINTRS
 10 NRDU\$
 11 NIO1\$
 12 NIO2\$
 13 NWDU\$
 14 SQRT
 15 NSIOP\$

RAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

01	000026	1L	0000	006764	100F	0000	007014	101F	0000	007022	1
00	007036	104F	0000	007044	105F	0000	007052	106F	0000	007062	1
00	007101	109F	0000	007116	110F	0001	000011	110G	0000	007120	1
00	007141	113F	0000	007156	114F	0000	007160	115F	0000	007174	1
00	007225	118F	0000	007240	119F	0000	007253	120F	0000	007257	1
01	000150	157G	0001	000171	170G	0001	000205	176G	0001	000055	2
00	007021	201F	0001	000224	206G	0001	000245	217G	0001	000260	2
01	000455	301G	0001	000474	310G	0001	000515	322G	0001	000530	3
01	000551	343G	0001	000553	347G	0001	000574	356G	0001	000703	4
01	000723	427G	0001	000741	51L	0001	000753	52L	0001	000765	5
01	001002	55L	0000	R 006654	ATA	0000	R 006731	EFOUT	0000	R 006717	F
00	I 006736	INDIC	0000	I 006712	IVAR	0000	I 006725	IS	0000	I 006745	I
00	I 006752	JK	0000	I 006750	JL	0000	I 006760	K	0000	I 006751	K
00	I 006754	LM	0000	I 006733	N	0000	I 006726	NL	0000	I 006746	N
00	I 006730	NV	0000	I 006727	NV1	0003	L 000000	OPTION	0000	R 005670	R
00	R 006737	SY	0000	R 006744	TL	0000	R 006741	TNU	0000	R 006743	T
00	R 000000	X	0000	R 006753	Y	0000	R 006757	YL	0000	R 006755	Y

1*	C	
2*	C TITLE	LSRP - LEAST SQUARES MULTIPLE REGRESSION PROGRAM
3*	C	WITH PREDICTIONS.
4*	C	
5*	C AUTHOR	R.R.SINGERS
6*	C	
7*	C SPONSOR	G.R.ANDERSEN
8*	C	
9*	C DATE	DECEMBER, 1970
10*	C	

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

11*	C	KEY WORDS	REGRESSION
12*	C		LEAST SQUARES
13*	C		PREDICTIONS
14*	C		
15*	C	PURPOSE	TO COMPUTE THE LEAST SQUARES REGRESSION COEFFICIENTS
16*	C		AND PREDICTION VALUES WITH UPPER AND LOWER
17*	C		PREDICTION LIMITS.
18*	C		
19*	C	METHOD	THE PROGRAM IS DESIGNED IN AN INTERACTIVE MODE
20*	C		ASKING FOR CERTAIN PARAMETERS AND DATA SERIES.
21*	C		THE STANDARD BACKWARD REGRESSION TECHNIQUE IS
22*	C		USED.
23*	C		
24*	C	SUBROUTINES	REBSOM - UNIVAC 1108 STAT-PACK BACKWARD
25*	C	USED	REGRESSION SUBROUTINE.
26*	C		
27*	C	NOTE	1) A DYNAMICALLY ASSIGNED FILE (UNIT 8) IS
28*	C		USED TO SAVE THE PREDICTED VALUES AND THE
29*	C		UPPER AND LOWER PREDICTION LIMITS.
30*	C		
31*			PARAMETER MXN=500,MXNP=5
32*			PARAMETER MXNP1=MXNP+1
33*			DIMENSION X(MXN,MXNP1),R(MXN),ATA(MXNP,MXNP1),
34*			IVAR(MXNP),FMT(6)
35*			LOGICAL OPTION
36*			READ(5,200,END=53)FMT
37*	200		FORMAT(6A6)
38*			IF(OPTION('N'))GO TO 1
39*			WRITE(6,100)
40*	100		FORMAT(/' LSRP IS A STEPWISE MULTIPLE REGRESSION PROGRAM'
41*			,' WITH PREDICTIONS.'/) THE PREDICTION RESULTS ARE STORED
42*			,'(IF DESIRED) ON UNIT 8.')
43*	1		WRITE(6,101)
44*	101		FORMAT(' NUMBER OF OBSERVATIONS?')
45*			READ(5,201,END=53)NL
46*	201		FORMAT()
47*			IF(NL.GT.MXN)GO TO 51
48*			WRITE(6,102)
49*	102		FORMAT(' NUMBER OF VARIABLES(DEPENDENT AND INDEPENDENT)?')
50*)
51*	2		READ(5,201,END=53)NV1
52*			NV=NV1+1
53*			IF(NV1.GT.MXNP)GO TO 52
54*			WRITE(6,103)
55*	103		FORMAT(' F LEVEL?')
56*			READ(5,201,END=53)EFOUT
57*			WRITE(6,104)
58*	104		FORMAT(' DEPENDENT VARIABLE FORMAT?')
59*			READ(5,200,END=53)FMT
60*			WRITE(6,105)
61*	105		FORMAT(' DEPENDENT VARIABLE DATA:')
62*			READ(5,FMT,END=53)(X(I,NV),I=1,NL)
63*			N=NV1-1
64*			DO 3 L=1,N
65*			WRITE(6,106)L
66*	106		FORMAT(' INDEPENDENT VARIABLE',I2,' FORMAT?')
67*			READ(5,200,END=53).MT

SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

68*      WRITE(6,112)L
69*      3      READ(5,FMT,END=53)(X(I,L+1),I=1,NL)
70*      DO 9 I=1,NL
71*      9      X(I,1)=1.
72*      CALL REBSOM(X,NL,NV1,MXN,MXNP,EFOUT,VARY,R,ATA,INDIC,IVAR
73*      ,554,555)
74*      SY=SQRT(VARY)
75*      NU=NL-INDIC
76*      WRITE(6,107)NU
77*      107     FORMAT(' T-VALUE FOR NU=',I3,' DEGREES OF FREEDOM?')
78*      READ(5,201,END=53)TNU
79*      WRITE(6,108)SY
80*      108     FORMAT(' STANDARD ERROR OF Y',F13.7)
81*      WRITE(6,109)
82*      109     FORMAT(' VARIABLE COEFFICIENT          S.D.    UPPER T    LOWE
83*      .R T'/' (0=CONST.))
84*      DO 4 I=1,INDIC
85*      SDC=SY*SQRT(ATA(I,I))
86*      TU=ATA(I,NV)+TNU*SDC
87*      TL=ATA(I,NV)-TNU*SDC
88*      I1=I-1
89*      4      WRITE(6,110)I1,ATA(I,NV),SDC,TU,TL
90*      110     FORMAT(I10,4E11.5)
91*      WRITE(6,111)
92*      111     FORMAT(' PREDICTION DATA:/' NUMBER OF PREDICTION VALUES?
93*      .')
94*      READ(5,201,END=53)NPR
95*      DO 5 I=1,N
96*      WRITE(6,106)I
97*      READ(5,200,END=53)FMT
98*      WRITE(6,112)I
99*      112     FORMAT(' INDEPENDENT VARIABLE',I2,' DATA:')
100*      5      READ(5,FMT,END=53)(X(J,I+1),J=1,NPR)
101*      DO 10 J=1,NPR
102*      10      X(J,1)=1.
103*      WRITE(6,113)
104*      113     FORMAT (' PREDICTED VALUES:/' NUMBER PREDICTION    UPP
105*      .ER T    LOWER T')
106*      DO 8 JL=1,NPR
107*      DO 6 KL=1,NV
108*      R(KL)=0.
109*      DO 6 JK=1,INDIC
110*      6      R(KL)=R(KL)+X(JL,JK)*ATA(JK,KL)
111*      Y=0.
112*      DO 7 LM=1,INDIC
113*      7      Y=Y+R(LM)*X(JL,LM)
114*      Y=SY*SQRT(1.+Y)
115*      YPR=R(NV)
116*      YU=YPR+TNU*Y
117*      YL=YPR-TNU*Y
118*      X(JL,1)=YPR
119*      X(JL,2)=YL
120*      X(JL,3)=YU
121*      8      WRITE(6,114)JL,YPR,YU,YL
122*      114     FORMAT(I7,3E13.7)
123*      WRITE(6,115)
124*      115     FORMAT(/' DO YOU WANT THE PREDICTION VALUES AND LIMITS SA

```


SINGERS/TSAP - TIME SERIES ANALYSIS PACKAGE//

```

125*      .VED(YES/NO)?')
126*      READ(5,200,END=53)I
127*      IF(I.NE.'YES')GO TO 53
128*      WRITE(6,116)
129*      116      FORMAT(' OUTPUT FORMAT?')
130*      READ(5,200,END=53)FMT
131*      CALL CSF(2,'DASG,T 8,F',J)
132*      WRITE(8,FMT)((X(J,K),J=1,NPR),K=1,3)
133*      WRITE(6,117)
134*      117      FORMAT(/' SERIES STORED IN FOLLOWING ORDER:/'
135*      .          ' PREDICTION SERIES,LOWER LIMIT SERIES,UPPER LIMIT SERIES
136*      ..')
137*      GO TO 53
138*      51      I=MXN
139*      WRITE(6,118)I
140*      118      FORMAT(' NUMBER OF OBSERVATIONS MUST BE LESS THAN',I5,
141*      .          ' TRY AGAIN.')
```

```

142*      GO TO 1
143*      52      I=MXNP
144*      WRITE(6,119)I
145*      119      FORMAT(' NUMBER OF VARIABLES MUST BE LESS THAN',I5,
146*      .          ' TRY AGAIN.')
```

```

147*      GO TO 2
148*      53      WRITE(6,120)
149*      120      FORMAT(' LSRP TERMINATES.')
```

```

150*      CALL EXIT
151*      54      WRITE(6,121)
152*      121      FORMAT(/' *** ATA MATRIX OF REBSOM SINGULAR ***')
```

```

153*      GO TO 53
154*      55      WRITE(6,122)
155*      122      FORMAT(/' *** NO VARIABLES LEFT IN REGRESSION ***')
```

```

156*      GO TO 53
157*      END
```

END OF COMPILATION: NO DIAGNOSTICS.

REFERENCES

1. Alvia, A. S. and Jenkins, G. M., An Example of Digital Filtering, Applied Statistics 14, 70 (1965).
2. Amos, D. E. and Koopmans, L. H., Tables of the Distribution of the Coefficient of Coherence for Stationary Bivariate Gaussian Processes, Sandia Corporation Monograph, March 1963.
3. Blackman, R. B. and Tukey, J. W., The Measurement of Power Spectra, Dover Publications, Inc., New York (1958).
4. Dixon, W. J., (Editor), BMD, Biomedical Computer Programs, University of California Publications in Automatic Computation, 1967.
5. Durbin, J., The Fitting of Time-Series Models, Revue Inst. Int. De Stat. 28, 3, 1960.
6. Gentleman, W. M. and Sande, G., Fast Fourier Transforms--For Fun and Profit, Proceedings of the Fall Joint Computer Conference, 1966.
7. Goodman, N. R., Measuring Amplitude and Phase, Journal of the Franklin Inst., 270, 6 (1960).
8. Grenander, U. and Rosenblatt, M., Statistical Analysis of Stationary Time Series, John Wiley & Sons, New York, 1957.
9. Hannan, E. J., Multiple Time Series Analysis, John Wiley & Sons (to appear).
10. Hannan, E. J., Regression for Time Series, Proceedings of the Symposium on Time Series Analysis, June 11-14, 1962, edited by Murray Rosenblatt.
11. Harris, B., (Editor), Advanced Seminar on Spectral Analysis of Time Series, John Wiley & Sons, 1967.
12. Jenkins, G. M. and Watts, D. G., Spectral Analysis and its Applications, Holden Day, San Francisco, 1968.
13. Univac 1108 - FORTRAN V, Programmer's reference, UP-4060 Rev. 1.
14. Univac 1108 OPERATING SYSTEM - EXEC 8, Programmer's reference, UP-4144 Rev. 1.